Flinders University
Australian Industrial Transformation Institute

Australian Sovereign Capability and Supply Chain Resilience

Perspectives and Options

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Executive Summary

The COVID-19 pandemic has led many nations to ask whether and in what domains, a greater degree of self-sufficiency should become an explicit national goal. These concerns with sovereign capability are especially prominent for Australia, which has deindustrialised over the past quarter century making it more vulnerable to supply chain shocks at a time of global crisis. It should be of great concern to policymakers that Australia has the highest dependency on manufactured imports - and the lowest level of manufacturing self-sufficiency - of any OECD country, leading to serious deficits in Australia's sovereign capabilities.

Sovereign capability is deeply rooted in the broader concept of strategy and is strongly connected to and reliant upon the nation's industrial structure. To make the case for sovereign capability is to make the case for industrial policy, to develop capabilities where they are needed, to help steer the development of the nation's industrial structure, and to reindustrialise.

Exactly what is meant by sovereign capability and how it is measured is contested. This report addresses this reality and the need to progress towards an agreed definition to guide policy development and practice.

For Australia particularly, achieving required sovereign capability is fundamentally about two things: production and policy. How these are defined shapes how adequate our conception of sovereign capability is:

- Production: is broadly conceptualised to take in activities such as design, systems integration, through-life support, and others, in addition to direct production. However, direct production is almost always the condition for the successful capture of vital pre- and post-production elements. Sovereign capability is not achieved without the ability to produce goods that are of strategic value and importance to the national interest.
- Policy: the extent to which government prioritises sovereign capability imperatives to identify and then address the decisive points for leverage and impact. This requires conscious and purposeful directions-setting for the future development of the economic, technological, organisational, logistic and operational capacities of the nation. The potential for government spending in the form of advanced procurement to bring new capabilities into existence, is vital for securing sovereign capability.

Sovereign capability is fundamentally about ensuring a degree of self-sufficiency and security for a nation and avoiding the vulnerability of external dependency in key areas of national interest including national defence, population health, security of energy and essential materials, food, and environmental sustainability (climate abatement and response).

Covid-19 has forced Australian policymakers to pay greater attention to sovereign capability in domains beyond defence industry. But the Australian Government has yet to commit to the development of a comprehensive national strategy based on a robust assessment of our strengths and vulnerabilities. By contrast, in the US, the Biden administration has commissioned a far-reaching top-down review of the state of its supply chains and domestic industrial capability in key sectors. In Australia, despite public anxiety about the lack of self-sufficiency revealed by the pandemic, the response has been subscale and piecemeal. In Australia, sovereign capability remains an explicit goal only in defence, which is also the only area deemed to require a dedicated sectoral policy. Even in defence, definitions and aims are inconsistent,

and have been diluted over time. Australia continues to lack a national industrial policy and strategy. Australia could adopt and adapt the US comprehensive and strategic approach with great benefit.

Internationally, although the term 'sovereign capability' is not in common use, international policies and strategies refer to related concepts under different names. Through alternate terms 'sovereign capability' is discussed internationally in defence, security and industrial policies.

Given Australia's policy and strategic immaturity, definitions and measurements pertinent to sovereign capability and industrial participation in major projects are extremely minimalist and loose (see Section 4). This expands the scope for avoidance and underachievement of even modest quantitative local content and dollar value goals. There is little consistency in the definitions of Australia work (content) or Australian industry. Nowhere are minimum levels of Australian content mandated. Stronger value-based targets are critical.

Even within the current limited quantitative criteria, sovereign capability considerations play little part. The approach is about the proportion of major contract value received, rather than about what we need to be able to make or do to achieve some level of independence and self-sufficiency. Sovereign capability entails targeting the decisive points in the value chain, especially in production, to decide what Australia must be able to make and do. Australia's passive non-directional approach contrasts with robust approaches evident in the Biden Executive Order on supply chains and sovereign capability, amongst others.

To understand the nation's interests in key nominated areas, and move towards securing the required degree of self-sufficiency, consideration must be given to:

- Existing industry structures for each industry domain
- The specific character of international value chains pertaining to each domain
- The differing significance of foreign ownership in each sector or domain
- The decisive points along the specific value chain, control of which will lead to the greatest degree of:
    - Industrial sovereignty (what we need to be able to make)
    - Operational sovereignty (what we need to be able to do).

It is possible to apply this approach in Australia. Existing sovereign capabilities in the five industry domains are assessed (see Section 5). Taking account of the current characteristics (role of multi-national corporations (MNCs) and foreign ownership, the preponderance or otherwise of small and medium enterprises (SMEs), etc.) of each domain, the nature and extent of external dependence of the sector, key gaps in sovereignty, and what an adequate level and nature of sovereignty for Australia requires, the state of each domain is summarised in Table 1, with details below:

Table 1: Operational and industrial capability level

Domain	Operational capability	Industrial capability
Health	High	Low
Defence	Medium-high	Low-medium
Energy, resources & infrastructure	Low	Low
Science, communications & technology	Low-medium	Low
Advanced manufacturing	Low	Low

- **Health**: Australia has high operational capability (it can do many things through a strong healthcare services and research sector) but low industrial capability (it can make relatively few things). In pharmaceuticals Australia has lost productive capability. Some leading MNCs and Australian-owned companies are present but with only limited productive capacity and capability.
- **Defence**: Australia has medium-high operational capabilities, alongside low-medium productive capabilities - a position that may improve through the application of advanced procurement and sectoral policies, although there is pressure to dilute these policy aims. However, the policy has attempted to ensure MNCs which operate as lead customers in the value chain commit to a level of local production and help support development of the capabilities of locally-owned SMEs.
- **Energy, resources and infrastructure**: Australia has largely regressed to be an exporter of unprocessed raw materials for offshore value-adding, alongside maximum import reliance for upstream plant, equipment and technology, and domination by overseas owned and revenue-repatriating MNCs. In energy and resources, the policy has been the mirror opposite of the stated policy goals in defence. Here low productive capability directly reduces operational capability and sovereign capability. It has reduced Australia's energy self-sufficiency and ability to make goods of strategic importance in the event of major supply chain disruption.
- **Science, communications and technology**: Across this highly diverse sector, operational capabilities are, on the whole, low to moderate, with industrial capability low. Research capabilities are frequently high, but they exist in a national policy vacuum and a weak industrial ecosystem. They seldom go beyond early-stage commercialisation and do not involve production. The outsourcing wave that commenced a quarter century ago strengthened reliance on MNCs and was focussed on reduced costs of service delivery at the expense of developing local capabilities.
- **Advanced manufacturing**: low productive capabilities also translate to low operational capabilities and low self-sufficiency frequently resulting in inability to make goods of strategic importance in the event of major supply chain disruption. This has additional significance because manufacturing inputs are of strategic importance across all the other industry domains assessed. The sector primarily comprises locally-owned SMEs that today lack the connections to large-scale complex industry verticals, of the type formerly provided by the automotive sector.

Sovereign capability can usefully be viewed on a spectrum. Critical issues include those related to the levels and nature of production occurring in Australia, the differential interplay of this with foreign ownership in each sector, and the character and structure of global value chains pertinent to the industry domain.

Practical visions are provided for each industry domain. These consider what the best targets and options are for increased sovereign capability and, the decisive points for focus and eventual

capture of the required capabilities. This includes indications of key broad actions required to increase Australian sovereign control.

Key observations include:

Policy Setting

- Foreign ownership has differential impacts on sovereign capability across the sectors. But this is less a function of foreign ownership itself, than of adopted policy.
- In defence MNC lead customers are expected to commit to certain levels of local production and value chain development, whilst resources and energy policy has directly favoured export of unprocessed raw materials and low minerals and energy self-sufficiency. A similar point applies to medical devices and pharmaceuticals.
- Addressing these policy-created weaknesses will require interventionist policies including:
    - Sector and development plans to secure local production
    - Preparedness by the national government to negotiate with MNCs for local production and associated supply chain development
    - Explicit ex-ante contractual provisions and agreements with MNCs, primes and lead customers to ensure local content and industry participation, including:
        - Direct production
        - Design
        - Systems integration and 'system of systems' integration
        - Other critical technologies
        - Extending production capabilities and Australian value chain participation over time.

Production Capabilities

- In almost all cases the presence or absence of production capabilities is decisive as to whether other capabilities relating to design, systems integration, technological innovation, and overall operational capability can be captured.
- Where possible Australia should adopt a portfolio approach to key projects and development of sovereign capability. This means, for example, in naval shipbuilding or major energy projects, every attempt should be made to build scale and opportunities for acquisition of key capabilities across concurrent projects within the sector, or across them (such as utilising crossovers between shipbuilding and offshore energy developments)
    - This should include consideration of an expert national authority responsible for the design of and monitoring of performance against ex-ante quantitative and qualitative targets, and consideration of ways of aggregating projects to build synergies and complementarities, amongst other things.

Government Leadership

- Adoption of national goals and strategies relating to energy self-sufficiency, as well as self-sufficiency in basic metals such as steel and aluminium, explicit secondary processing and value-adding strategies for a portfolio of Australian natural resources, and a comprehensive national manufacturing strategy.
- In infrastructure, stronger agreements concerning continuity of access and use may be necessary. This applies to both Australian and foreign owners of such assets, although

the means required will differ in each case. In some areas, particularly energy, it may be necessary for public ownership to be resumed in certain parts of the network.

- Levels of domestic supply of critical inputs, including a degree of redundancy, will need to be mandated and enforced: gas, oil and petroleum, pharmaceuticals, etc.

An approach based on identifying the decisive points and applying resources and force at those points for maximum impact is a strategic approach. It recognises that limited resources and capacity for force cannot be effective if it is expended in any and all directions. It must be directed at a target. Australian ownership may be important as a means of sovereign control in one domain, but not in another where sovereign capability may be secured by other means.

The scope of this inquiry does not involve precise specification of the decisive points for greater sovereignty in each sector. That would require a much more comprehensive set of studies along the lines of the top-down Biden Executive Order on supply chains and sovereign capability. The present study indicates where to look for this later specification.

1 Introduction

The term 'sovereign capability' achieved global prominence in 2020 in response to the impact of COVID-19 on global supply chains. Debate ensued about Australia's capability to ensure supply of critical goods and services during times of crisis. This raised questions about what domestic capability and capacity we have in the face of significant events or changed circumstances, as well as what strategic industrial capabilities and operational capabilities might be required in the future. Supply chain disruptions are not always predictable and attempts to rectify deficits in sovereign manufacturing capabilities after supply chains have been disrupted will likely be ineffective, inefficient, and expensive. The COVID-19 crisis dramatised and enlarged the level and breadth of prior public concern about Australia's high dependency on overseas production for even basic goods essential to public health. Practical consequences of a historical process of deindustrialisation were laid bare. The increased risk of supply chain disruptions in the future due to the compounding effects of increasing uncertainty in the Indo-Pacific region (Commonwealth of Australia, 2020a) and climate change, together with the cumulative impacts of the ongoing pandemic and awareness of the future possibility of others, highlights the imperative to identify and rectify vulnerable supply chains before further disruption occurs.

Sovereign capability is a concept deeply rooted in the broader concept of strategy. That is, how can a nation best deploy limited and defined resources and force (means) against an enemy or challenge at the decisive points for maximum impact (object) (von Clausewitz, 1832). We adopt this broad approach, focussing particularly on sovereign industrial capabilities – what must Australia be able to make – and sovereign operational capabilities – what must Australia be able to do – to achieve the required degree of sovereignty and avoid external dependency in key areas of national interest?

In the US, the Biden administration has announced an ambitious and comprehensive top-down review of supply chain resilience, capability, and stability, nominating key areas for independent sovereign capability. This Executive Order commenced with a 100-day supply chain review into supply chain risks in semiconductor manufacturing and advanced packaging, high-capacity batteries including electric vehicle batteries, critical minerals and other strategic materials, and pharmaceuticals and pharmaceutical ingredients. This is to be followed by comprehensive sectoral supply chain assessments into industrial capabilities, gaps and weaknesses in the sectors of defence, public health and biological preparedness, ICT, energy, transportation and food and agriculture. Each report will identify the critical goods and materials required by the supply chain, the manufacturing and production capabilities necessary to each, assess the various risks to the supply chain, together with the capacities of US manufacturing and agricultural supply chains to support national security, economic capability and emergency preparedness.

Although the pandemic has exposed critical weaknesses in Australia's industry structure and its industrial and operational capabilities, the national policy response has been far more piecemeal. In the initial stages of the COVID-19 pandemic and subsequent lockdowns, Australian industry and government scrambled to re-orient domestic manufacturing towards the production of health and medical equipment. Shortages of simple products like face masks and hand sanitiser were experienced, revealing major capability and capacity gaps, and fuelling public anxiety. Ultimately, existing capabilities were crucial in ensuring that Australian businesses were able to supply enough personal protective equipment (PPE) to keep Australians safe. At the start of the pandemic, the total capacity for surgical mask manufacturing in Australia was estimated to be 37 million per year. In 2020, more than 200 million surgical masks were manufactured in Australia

(Riley, 2020c). Had COVID-19 not been largely well contained in Australia (through border closures and inherent island-continent advantages), shortages of medical equipment may have emerged as a major contributor to the incidence and severity of the virus. Indeed, these concerns have resurfaced with a slow vaccine rollout and the advent of new variants of concern.

The benefits of sovereign capability stretch beyond strengthening Australia's sovereignty and self-sufficiency. Through a stronger industrial base, Australia would realise increased economic growth, improved and protected health and wellbeing of Australian citizens, and greater participation in international value chains. Sovereign capabilities better position Australia to supply its own products of need, and to maintain an industrial capability base which can be redirected in times of crisis. Additionally, sovereign capabilities in Defence, including a sovereign fuel supply and on-shore processing, design and repair capabilities, and parts manufacturing, are necessary to ensure Australia's ability to defend itself, if necessary, and keep its citizens safe. Indeed, the manufacture of Australian defence equipment has long been the focus of the debate concerning sovereign capability. In recent times this has focused on maritime shipbuilding and the objective of government to ensure high levels of Australian industry content and employment through these very large-scale projects.

The goal of securing supply chains is not to isolate Australia from the rest of the world. Sovereign capability is not isolationist. It is not the position of the government to supply everything it wants entirely from local sources (The Hon Karen Andrews MP, 2020a), but it now concedes fragility in certain supply chains does need to be addressed. Relative to other nations, particularly the United States, Australia's response remains immature, lacking the robust examination of the vulnerability of key supply chains that is required to inform policy and action. The $1.5 billion Modern Manufacturing Strategy announced in the 2020-21 Federal budget provides funding for businesses to integrate their products and services into domestic and global value chains in sectors relating to the national manufacturing priorities of space, medical products, resources technology and critical minerals processing, food and beverages, defence, and recycling and clean energy. The objective of this scheme is to support Australian manufacturing businesses to, inter alia, support Australian manufacturing businesses and entrepreneurs to participate in local and global value chains.

An appropriately scaled effort to accelerate the growth of high value manufacturing would make an important contribution to growing knowledge intensive employment and improving living standards. This is because supply chains encompass more than sourcing the intermediate inputs for a final product. They also relate to the supply of labour, and the supply of ideas, designs, and patent rights. Building resilient supply chains involves securing any one or more of these inputs. Critically, supply chain capability also means the capacity to provide good through-life support and technology upgrades to long-life infrastructure and assets. In Defence for example, the ability to produce some products and services almost completely independently will be essential. In other industries, improving and building local capabilities provides additional benefits in terms of economic growth, increased research and development, providing local jobs, increasing business revenues by generating export opportunities, and the development of an industrial base with critical mass of manufacturing capabilities able to be leveraged and re-oriented if required.

Sovereign capability entails an understanding of what are the decisive points along the relevant value chain or in the defined industry vertical. These need to be identified in each instance according to the specific characteristics of each domain in question. Moreover, the nature of these decisive points will change over time, requiring the strategy to be a living and not a fixed one. However, the presence or absence of certain production capabilities,

regardless of the importance of other parts of the value chain, will be determinative of the level and quality of Australia's future sovereign capabilities. Production capabilities will seldom be a sufficient condition of Australia sovereign capability but will almost always be the necessary condition. There is no logical reason why a ship or other asset not built in Australia and purchased off the shelf would contain sufficient design specifications appropriate to Australia's operational and strategic needs, nor that complex systems integration would meet those needs in such cases.

In making the case for sovereign capability one is necessarily also making the case for industrial policy to help steer the nation's industrial structure in desired directions and, in Australia's case, for reindustrialisation. Sovereign capability involves these dimensions and has benefits relating to industrial development, knowledge-intensive industries, and so on.

However, sovereign capability is itself fundamentally about ensuring for the nation a degree of self-sufficiency and security and avoiding external dependency in key areas of national interest such as: national defence, population health, security of energy and essential materials, food, and environmental sustainability and climate abatement and response. It is fundamentally about:

- Sovereign industrial capabilities – what must Australia be able to make?
- Sovereign operational capabilities – what must Australia be able to do?

1.1 The brief

The Australian Sovereign Capability Alliance (ASCA) has requested that AITI provide analysis of the nature, definitions and requirements of Australian sovereign capability in five key industry domains. The broad goal is to determine what Australia must be able to build, make, control, or know to guarantee its independence and sovereignty.

This report assesses material from the Australian government, academia, and industry to discuss and identify definitions of sovereign capability, Australian industry content, Australian enterprise, and Australian work. Five key industry domains are analysed to determine where there is consensus and where there is disagreement. These are Health, Defence and Space, Energy Resources and Infrastructure, Science, Communications and Technology (SCT), and Advanced Manufacturing. These industry domains are similar but not identical to sectors targeted for policy and program support in the 2020 Modern Manufacturing Strategy statement (The Hon Karen Andrews MP, 2020b) which are resources technology and critical minerals processing, food and beverage, medical products, recycling and clean energy, and defence and space.

Within each of the ASCA-nominated domains, the key sovereign *industrial* and *operational* capabilities are identified. Additionally, best practice international and national data are examined to identify Australia's ranking in sovereign *operational*, *industrial* and *enabling* capabilities. Data and explicit sources relating to these issues are limited and partial. Definitions are for the most part ad hoc and inconsistent. This means the present analysis proceeds by using the best available information relevant to the specific industry domain and suggesting future directions and actions for examination.

Definitions of the current use of key indicator terms such as sovereign capability, Australian industry content, Australian enterprise and Australian work are reviewed where available. We look at improved definitions of these concepts in brief. We examine the characteristics of a set of more adequate robust definitions. Their further specification would be an element of separate future work. An adequate sovereign capability strategy framework will provide definitions and

criteria specific to the industry domain, recognising key sectoral differences. This is not to be confused with the current position in which a lack of consistency and rigour prevail.

Finally, the report provides key facts on the general underlying horizontal capabilities and issues of competitiveness (e.g., education, research and development), the presence or absence of which either supports or undermines sovereign capability aims and goals.

2 Industrial structure and sovereign capability

2.1 National sovereignty and sovereign capability

No comprehensive or all-encompassing definition or set of concepts concerning sovereign capability currently applies to the ASCA nominated industry domains in Australia. This is not because definitions of sovereign capability and its requirements of necessity differ across industry sectors, places and times, as they must, but rather, because sovereign capability has not been a national policy objective for at least the past quarter century. Indeed, in segments of the policy debate over that period, the idea that the nation should endeavour to secure certain key minimum industrial capabilities has been travestied as anti-trade, anti-competitive and protectionist. This is particularly so in Australia.

Ultimately, this led to the virtual rejection of industrial policy and strategy altogether. The sole exception has been defence which has warranted dedicated sectoral policies and programs, on explicit sovereign capability grounds. For this reason, concepts of sovereign capability applied to this sector are clearer than other industry sectors and domains, although even here they are frequently imprecise and elusive.

Concepts of sovereign capability are best seen as derivative of broader and older ideas of sovereignty generally and national sovereignty in particular. National sovereignty refers to the capacity of a nation state to govern itself, by applying powers to make and enforce laws, levy taxes, make war and peace, enter into agreements and commerce with foreign nations, without foreign interference. Sovereign capability extends these concepts to take into consideration the industrial, economic, logistical, research and educational capabilities required by a nation state to achieve desired objectives. These may relate to the nation's defence and the safety of its population, the health of the population, security of food supplies, the provision of essential water, power and communications infrastructure.

Sovereign capability is a concept rooted in the broader concept of strategy, that is, how best to deploy limited and defined resources and force (means) against an enemy or challenge at the decisive point(s) for maximum impact (object) (von Clausewitz, 1832). Sovereign capability entails an understanding of what are the decisive points along the relevant value chain or in the defined industry vertical. These need to be identified in each instance according to the specific characteristics of each domain in question. Moreover, the nature of these decisive points will change over time, requiring the strategy to be a living and not a fixed one. However, the presence or absence of certain production capabilities, regardless of the importance of other parts of the value chain, will be determinative of the level and quality of Australia's future sovereign capabilities. Production capabilities will seldom be a sufficient condition of Australia sovereign capability, but will almost always be the necessary condition.

A concern with sovereign capability is, therefore, not to be confused with or misrepresented as support for autarchy, that is, an economy closed to trade seeking self-sufficiency across the board.

2.2 Industrial structure

A concomitant of sovereign capability is necessarily also a concern about the nation's industrial structure and industrial capabilities. Sovereign capability is a dynamic concept the precise meaning and content of which will vary between nations, sectors, places, and times. What will constitute sovereign capability in one sector will be different in another; what it means in Australia will differ from other nations and today's requirements for Australian sovereign capability will not be the same as those in the past or future.

This again underlines the strategic character of the concept of sovereign capability. Securing sovereign capability means continuously aiming at a moving target for the acquisition and sustainment of essential capabilities. As soon as we speak of sovereign capability, we are speaking also of a nation's industrial structure and capabilities. Sovereign capability requires that the nation possess strategically important activities at various parts of the relevant value chains, from design to systems integration, to long-term sustainment and periodic technology upgrades. The presence or absence of production capabilities is central to sovereign capability as is the ability to capture associated capabilities outside production, such as design. Sovereign capability refers to the presence of key capabilities, particularly in production, and the sustainment of those capabilities and associated assets over time.

2.3 Australia's industrial structure

Over the past quarter century particularly, Australia's deindustrialisation has most graphically been highlighted by the dramatic decline in manufacturing output and employment, together with the emergence of an industrial structure more akin to a developing country than that of a high-income advanced economy. Australia's position in global trade is now largely an exporter of low value raw materials and commodities and an importer of high-end advanced manufactures.

Australia's manufacturing GDP share today is below 6 percent having declined almost continuously since 1995. The decline has been most pronounced since 2008, partly due to an inflated exchange rate following the resources boom. Australia produces the lowest proportion of manufactured products for its own consumption or use in the OECD, and Australia's level of manufacturing self-sufficiency is also the lowest among OECD countries. That import dependency centres on elaborately transformed, knowledge-intensive and complex manufactures (Stanford, 2020: 60-65). This is correlated to dramatically declining economic complexity with Australia declining to levels of complexity typical of a developing country. In 2018 Australia was 87th of 133 in scope nations, a fall of 20 places over the previous decade (The Growth Lab at Harvard University, 2019).

The following table clearly illustrates the structural imbalance in the Australian economy, and how structural change takes place in the absence of policy leadership and industrial strategy from successive governments. Today Australia is the lowest producer in the OECD of the manufactured products it consumes, and its dependency on imports therefore is the highest in the OECD.

Table 2: Australian manufacturing dependency

OECD nations	Gross Manufacturing Output ($US b)	Ratio of Manufactured Imports/Exports	Manufacturing Trade Balance ($US b)	Self-Sufficency Ratio
Ireland	215.4	0.3	109.4	203.2%
Germany	2013.9	0.6	347.1	120.8%
Luxembourg	12.6	0.7	2.1	119.7%
Netherlands	329.5	0.7	51.5	118.5%
Korea	1467.0	0.6	227.4	118.3%
Switzerland	334.4	0.8	40.5	113.8%
Hungary	99.9	0.8	10.9	112.2%
Sweden	203.0	0.8	21.8	112.0%
Finland	117.1	0.8	11.3	110.7%
Czech Rep.	169.4	0.8	16.1	110.5%
Slovenia	26.3	0.9	2.3	109.8%
Italy	995.5	0.8	85.4	109.4%
Austria	194.3	0.9	15.2	108.5%
Slovak Rep.	79.9	0.9	6.0	108.2%
Denmark	100.5	0.9	7.1	107.6%
Iceland	6.6	0.9	0.5	107.5%
Belgium	236.3	0.9	15.0	106.8%
Japan	2616.5	0.8	115.8	104.6%
Lithuania	21.3	0.9	0.6	103.1%
Israel	110.4	0.9	2.9	102.7%
Portugal	90.4	1.0	2.1	102.3%
Spain	613.7	1.0	6.2	101.0%
Poland	302.7	1.0	-0.5	99.8%
France	802.4	1.1	-23.0	97.2%
Estonia	12.3	1.1	-0.4	96.6%
Mexico	699.7	1.1	-30.2	95.9%
New Zealand	64.1	1.2	-3.5	94.8%
Turkey	483.8	1.3	-38.2	92.7%
U.S.	5744.5	1.8	-711.4	89.0%
Canada	596.0	1.4	-74.4	88.9%
Greece	57.9	1.6	-10.2	85.0%
U.K.	744.3	1.6	-149.8	83.2%
Latvia	9.2	1.5	-2.0	82.2%
Norway	100.1	2.1	-30.8	76.5%
Chile	83.5	2.3	-27.5	75.2%
Australia	269.2	2.8	-107.2	71.5%

Source: Stanford (2020)

Two further features of Australia's deindustrialisation should be underlined. First, over the past quarter century, directly resulting from the lack of policy leadership and industrial strategy, Australia's capacity to add value to its resource endowments through secondary processing has declined. Australia's resource exports today are less processed and less sophisticated than the mid-1990s. Many criticisms of outcomes from Australia's resources expansion and the nation's overreliance on these extractive sectors miss the fundamental point that individual companies are to be expected to maximise their returns and minimise costs. In the case of the extractive industries, these interests are powerfully shaped by high levels of foreign ownership and the ability to extract raw materials at source. The issue is that national policy settings enable and encourage behaviour resulting in low levels of value-adding to Australia's natural resources.

Second, alongside the dramatic absolute decline in size of manufacturing and its contribution to GDP, should be noted its vertical disintegration. The demise of automotive manufacturing, which had been Australia's most complex vertically integrated value chain, is illustrative of a broader trend. Australia's remaining manufacturers are, for the most part, no longer parts of an onshore industry vertical – a large scale interdependent value chain of complex lead customer and tiered supplier relationships. Within manufacturing itself, value chain linkages are likely to be distant and import dependent, and key value chain capabilities absent.

2.4 Australia's industrial policy

This industrial disintegration is not only reflected in current national policy: it is positively facilitated by it. The focus of policy is largely on generic 'horizontal' issues, impediments and market failures, and almost never on developing and securing high-value industry verticals or sectors identified as in the national interest. The only significant large-scale exception to this has been the dedicated sectoral policies for the development of defence industries, justified on sovereign capability grounds. This is specifically that national defence requires certain national industrial capabilities, for both evolving equipment and products to Australian needs, and for through-life support, technology upgrades, and sustainment.

Australia's deindustrialisation is not accidental but rather the outcome of specific policy settings, even where the policy was only partially applied, or where advocates did not intend dramatic deindustrialisation to be its result. Australia's current position is owed to the initially modest, and later ambitious, application of comparative advantage inspired policies over the past four decades, based on the removal of discriminatory industry support policies, in favour of relative price signals and freer markets (McLean, 2012). Comparative advantage holds that relative prices and resource endowments should determine Australia's industrial structure and its areas of specialisation.

This has entailed the rejection of industrial policy in principle at the national level, with pragmatic political concessions to intervention in cases of industry decline or closure, such as automotive, or with national defence capability, or with the recent Modern Manufacturing Strategy which accepts the need for some 'sovereign' industrial capacity to meet certain domestic medical and pharmaceutical requirements in case of a future crisis, together with a weak focus on certain other sectors. Even so, the recognition of the importance of domestic medical and pharmaceutical industrial capabilities has only occurred due to the significant threat of shortages in critical PPE for frontline healthcare workers at the beginning of the pandemic. This recognition is entirely reactive to present conditions, rather than strategic recognition of the need to help shape a new industrial structure for the nation. However, the Initiative is under scaled, lacking

specification of priority industry verticals for development, and fails to rise to the level of comprehensive national industrial policy and strategy (Green, 2020; Roberts, 2020).

3 Sovereign capability – a review of the literature

3.1 Introduction

This section presents the results of a review of the sovereign capability literature. Sovereign capability appears to be a term predominantly used in the context of the Australian Defence industry. Similar concepts such as supply chain resilience and supply chain assessments, health sovereignty, preparedness, and industry policy do appear in the broader international literature, and we use these as proxies in our exploration of the concept of sovereign capability.

Overall, there are no singular or incontrovertible definitions of sovereign capability. In many nations sovereign capability is not a term in wide use. Recently, however, the US has adopted a robust approach prioritising sovereign capability via resilient supply chains. In Australia, sovereign capability is prescribed in defence policy, and referred to increasingly in other industry domains, following the COVID-19 pandemic. However, the approach to sovereign capability in non-defence sectors is subscale. Further, definitions are not consistently applied across Australian industry. The overall approach is partial and patchy. This means that in Australia there is opportunity for quantitative targets and benchmarks to be avoided or diluted in practice.

A further finding is that although quantitative measures are vital, it is critical to apply qualitative and strategic criteria focussed on the 'decisive points' in a value chain and a production process that contribute most to the achievement of sovereign capability. The application of sovereign capability in the defence industry is used as a template for the other nominated industry domains, regardless of gaps and inadequacies in the defence framework, which are discussed.

Finally, this section takes in certain international lessons. Few nation states' policies explicitly reference sovereign capability as a goal, but it is nevertheless often present implicitly as a key facet of industrial policy. This is an illustration of the earlier point that sovereign capability should be linked to a desired industry structure for the nation in question.

3.2 Literature scan

A purpose was to unearth sources on international sovereign capability frameworks to compare to Australian practice and policy[1]. This study points to weakness, inconsistency, and often the complete lack of an overall framework and of definitions and measurements in Australia. We found no sources that systematically illuminate definitions of sovereign capability used in other nations, together with related supporting definitions and concepts of say, 'UK Industry Content', 'UK Enterprise' and 'UK Work', to provide bases for comparison.

[1] We used Google Scholar to search under 'sovereign capability'. This yielded predominantly Australian sources relating the defence industry. Recognising that other descriptions might be used to discuss the substance of sovereign capability concepts, we searched using similes to ensure capture of key information. These alternative descriptors included 'supply chain resilience', 'overall preparedness', sovereignty by relevant sector, for example, 'health sovereignty', and 'industry capabilities'. We also examined the Journal of Supply Chain Management.

This does not mean that considerations of sovereign capabilities are absent or sidelined from policies and strategies. Instead sovereign capability concepts are captured and discussed in defence and security policies, and in industrial policies. Hence this is the focus of attention in the following illustrations.

3.3 Biden Executive Order on 100-Day supply chain review and sectoral supply chain assessments

In contrast to the majority piecemeal approaches, the Biden administration has ordered a comprehensive top-down review of supply chain resilience, capability and stability, in nominated key areas for independent sovereign capability. It provides a stark contrast to Australia's industrial policy.

The process commenced with a 100-day supply chain review into supply chain risks in:

- Semiconductor manufacturing and advanced packaging
- High-capacity batteries including electric vehicle batteries
- Critical minerals and other strategic materials
- Pharmaceuticals and pharmaceutical ingredients.

These relate to identified immediate priorities and vulnerabilities. The process then expands into comprehensive sectoral supply chain assessments for delivery within a year of the order, as follows:

- Defence industrial base
- Public health and biological preparedness industrial base
- Critical sectors and subsectors of ICT
- Energy sector industrial base
- Transportation industrial base
- Agriculture and food industrial base.

Each of these reports identifies the critical goods and materials required by the supply chain, the manufacturing and production capabilities necessary to each, supply chain risks posed by defence, intelligence, cyber, homeland security, health, climate, environmental, natural, market, economic, geo-political and other issues, together with the capacities of US manufacturing and agricultural supply chains to support national security, economic capability and emergency preparedness.

There is particular focus on manufacturing to identify: critical needed capabilities, gaps in capabilities, single-point of failure supply chains (e.g., reliance on a sole supplier), location of production assets, availability of substitutes and alternative sources of goods and materials, education and workforce skills, research and development, the role of transportation systems, risks from climate change, actions required of international partners, and prioritisation of critical goods and materials. The process contemplates recommendations relating to reshoring of formerly outsourced supply chains, cooperation with international allies and alternative supply chains, building redundancy into domestic supply, building workforce capabilities, access to finance, research and development to broaden supply chains, addressing risks associated with digital products and technologies relied upon by the supply chain, and climate change.

The guiding Policy section of the Executive Order states:

The United States needs resilient, diverse, and secure supply chains to ensure our economic prosperity and national security. Pandemics and other biological threats, cyber-attacks, climate shocks and extreme weather events, terrorist attacks, geopolitical and economic competition, and other conditions can reduce critical manufacturing capacity and the availability and integrity of critical goods, products, and services. Resilient American supply chains will revitalize and rebuild domestic manufacturing capacity, maintain America's competitive edge in research and development, and create well-paying jobs. They will also support small businesses, promote prosperity, advance the fight against climate change, and encourage economic growth in communities of color and economically distressed areas.

More resilient supply chains are secure and diverse — facilitating greater domestic production, a range of supply, built-in redundancies, adequate stockpiles, safe and secure digital networks, and a world-class American manufacturing base and workforce. Moreover, close cooperation on resilient supply chains with allies and partners who share our values will foster collective economic and national security and strengthen the capacity to respond to international disasters and emergencies.
Therefore, it is the policy of my Administration to strengthen the resilience of America's supply chains."

The 100-Day Reviews under Executive Order 14017 (The White House, 2021) has recently appeared. Its general themes and approach support the principles and directions developed here independently. These include that the USA's political economy has, like Australia's, prioritised low costs and low wages over the security, sustainablity and resilience that comes from targeting a level of national production and capability, and that redressing the decades-long effects of this requires, amongst other things, a focus on taking the 'high road' of quality high-skill jobs, seeing the workforce as a wellspring of innovation, rebuilding the SME sector, and revaluing the role of government in setting key economic directions and countering current levels of inequality. Against the 'low road' that has been favoured in the US and Australia, Executive Order 14017 proposes a 'race to the top'.

It favours an array of industrialisation measures that include: a supply chain resilience program, use of the Defense Production Act to expand production in target areas, greater state intervention to help shape markets and strengthen supply chains, and 21st century standards for raw materials and their sustainable use.

Most of all, Executive Order 14017 provides a substantive and methodological model for the type of approach independently found necessary by our analysis. That is to say, it provides comprehensive and meticulous supply chain mapping, breaking the chain down to its key elements and stages, examines each stage having regard to the current situation, an analysis of competitors and suppliers, and defining and isolating the decisive points along the value chain required to increase or achieve sovereign capability in the sector.

3.4 Australian defence Industries

More than $200 billion has been committed by the Commonwealth to defence procurement and Australian industry development to 2027-28, under the national government's Defence White Paper and associated policy statements (Commonwealth of Australia, 2016a, 2016b, 2016c). This aims to modernise Australia's naval, land and airborne defence forces, whilst seeking to develop Australia's defence industries' size and capabilities. Australia's sovereign defence capabilities are seen to embrace not only operational and field capabilities of the forces, but also the industrial and technological capabilities of Australian industry and its supply chains. The defence industry is the only segment of Australian industry thus far considered to

warrant a strong vertical sectoral policy, comprising inter alia, largescale advanced procurement practices, domestic industry participation targets, and mission oriented and directional projects for new technology, product and process development. Defence procurement and the technological requirements of a modernised Australian defence capability set are here regarded as opportunities for development of new knowledge-intensive manufacturing and engineering industries, with long and strong supply chains, and with high economic benefits to the nation.

This approach to the development of sovereign capability is being complemented by organisations charged with helping to find key solutions to broad defence and industrial challenges, such as: the Defence Science and Technology (DST) Strategy 2030, focused on strategic research directed at high-impact outcomes over ten years, through eight priority research areas, or 'STaR Shots' (Science, Technology and Research Shot), recalling John F. Kennedy's Moon Shot of the 1960s; the Next Generation Technology Fund (NGTF) which supports research in emerging and future technologies and research and development (R&D) in "emerging and future technologies for the 'future Defence force after next'", through a mixture of 'Grand Challenges' and smaller scale 'lean focussed technology acceleration'; and the Defence Innovation Hub (DIH) which focusses on five Defence innovation priorities or streams with an SME priority. The Centre for Defence Industry Capability (CDIC) operates as active industry outreach using a geographically distributed model of business advisers. The CDIC works with companies and research institutions to facilitate development of proposals which are then assessed and approved by NGTF and DIH (Commonwealth of Australia, 2021).

However, practical results to date fall short of the ambition. In naval shipbuilding, the largest component of the overall procurement and investment program, local content provisions and targets are not mandated. Over time the terms of 'sovereign capability' have tended to be defined more narrowly, to focus on national security and operational capability, somewhat at the expense of the industrial sovereignty agenda (The Centre for Future Work, 2019).

Difficulties in the relationship between the Australian government as final customer and the Naval Group contracted to produce 12 submarines have received media attention. The program contract provisions state an expectation of Australian capture of only 60 percent of construction value and a moderate proportion of maintenance. Australian Industry Participation plans are not required to mandate the value of Australian content on projects. This allows large foreign-owned lead customers in publicly-funded major defence projects to avoid obligations to help develop the capabilities of local businesses and SMEs, and to instead import prefabricated componentry from overseas (The Centre for Future Work, 2019).

This underscores a further critical issue, both in the defence industry and the also foreign-dominated export resources sector, in particular. Although mandated dollar value local content provisions are essential, so too are provisions relating to the decisive points in the value chain that can make the largest contributions to achievement of sovereign capability. This includes a focus on capture of design and systems integration functions.

The nature of the systems and systems integration built into defence major projects often determines the nature and extent of value chain opportunities open to SMEs and for collaborative research aimed at solving problems and realising opportunities. Key technology and sourcing decisions are often already encoded in the systems and systems integration framework and will be certainly predetermined where an 'off-the-shelf' solution is chosen, and very often even when local industry participation policies are in place. The extent to which defence value chains can be opened to create these local industry opportunities will often be affected by public procurement

policies. But even where local content provisions apply, many of the highest value opportunities may be missed if decisions about the nature and location of design and systems integration are left to the 'prime' contractors. These may otherwise remain invisible and simply be rolled up into the prime's existing supply chains, even where there are local content obligations related to assembly and services.

Hence, qualitative (strategic) as well as quantitative criteria are required that define and target the decisive points for sovereignty. Measures applied to the quantitative performance of companies engaged in major Australian defence projects are often themselves loose and lacking in rigour and narrow in scope. These can often be crude dollar or aggregate job measures of Australian industry and workforce participation, not supplemented by discriminating criteria relating to which elements on the value chain need to be captured for sovereign capability. Moreover, the imprecision and inconsistency of these limited performance measures creates avenues for noncompliance and underperformance by large foreign-owned lead customers.

The 2016 White Paper and accompanying Defence Integrated Investment Program and Defence Industry Policy Statement enunciated quite ambitious sovereign capability goals, including domestic production:

> *There are some capabilities that are so important to Australian Defence missions that they must be developed or supported by Australian industry because overseas sources do not provide the required security or assurances we need. As such, it is critical that the industry base associated with these capabilities is maintained and supported by Defence as sovereign industrial capabilities.[…] The existing Priority and Strategic Industry Capability policy will be replaced by a Sovereign Industrial Capability Assessment Framework to improve the identification and management of the sovereign industrial capabilities that develop and support our ADF capabilities. (Commonwealth of Australia, 2016a, p. 23)*

Since that time, however, there appears to have been significant dilution:

> *It becomes a sovereign industrial capability when Australia assesses it is strategically critical and must therefore have access to, or control over, the essential skills, technology, intellectual property, financial resources and infrastructure as and when required. (Commonwealth of Australia, 2018c, p. 17)*

The Department of Defence has added further specificity to the 2016 papers (Commonwealth of Australia, 2016a, 2016b, 2016c) with ten nominated Sovereign Industrial Capability Priorities in the 2018 Defence Industrial Capability Plan (Commonwealth of Australia, 2018c). These are "the industrial capabilities that are critical to Defence and must be developed or supported by Australian industry" (Commonwealth of Australia, 2020a, p. 46) However, they appear in certain areas to dilute the role of industrial sovereignty and production. They comprise:

- Collins Class submarine maintenance and technology upgrade
- Continuous shipbuilding program (including rolling submarine acquisition)
- Land combat and protected vehicles and technology upgrade
- Enhanced active phased array and passive radar capability
- Combat clothing survivability and signature reduction technologies
- Advanced signal processing
- Surveillance and intelligence
- Test, evaluation, certification and systems assurance

- Munitions and small arms research, design, development and manufacture, and
- Aerospace platform deeper maintenance and structural integrity.

These each have implementation plans outlining priority capabilities within each of the domains. Overall, the focus of the implementation plans is on the development of operational capabilities, with markedly lesser emphasis on production capabilities. It is recognised across the domains that different capabilities are required, with the Australian government making judgements as to the optimal level of access to, or control over for each priority, on a case by case basis. The emphasis of "access to" or "control over" is a significant substitute for local production capabilities. Arising from these implementation plans is a modest suite of policy measures and business extension services, typically aimed at improving market access, intellectual property rights, digital security, and technology demonstration. In combat clothing for example, there is an explicit deference to offshore manufacturing, while in munitions and small arms research, the importance of local manufacturing capabilities is expressed.

The assumption of a trade-off between industrial and operational capability and sovereignty will often be questionable. This is because operational capability will often be adversely affected by the lack of knowledge about how a component works that comes from designing and producing it. Buying complex electronic systems off the shelf from overseas sources without acquiring the knowledge that comes from integrating and modifying them to domestic needs, also adversely affects operational performance and capability. Off the shelf overseas provision to Australian purchasers may often come with restrictions on access to IP that can make Australia less operationally sovereign, as well as less industrially capable. In almost every instance, the ability to design and integrate complex electronic systems depends upon a high level of local production and manufacture. Long-term operational capability also depends on local production.

3.5 Technology procurement

The US industrial policy has relied heavily on innovation-driven public procurement under the direction of a complex of agencies. Central to this complex are military and security industries and institutions originating in the Cold War, but since evolving to include additional sectors outside the military, such as energy and health, seeking to develop dual use technologies (Weiss, 2013). US procurement is described as "a *demand*-based instrument to 'pull' new technologies and products into the marketplace through competitive contracts backed by a ready buyer" (Weiss, 2013). This 'technology procurement' is distinct from general government contracting (buying goods and services off the shelf, already in existence and known to the buyer) as it actively deploys procurement to bring new goods, services and systems into existence, or adapting existing ones to new ends.

Technology procurement seeks a technology, product, or service that either does not exist or requires adaptation to new purposes. This typically takes the form of a challenge-based call for a technology, product, service, or system to solve a cluster of problems. In return, firms receive subsidised industrial research and development, insulation from import competition and a guaranteed market and sales on a cost-plus basis (Weiss, 2013) . Programs such as the Small Business Innovation Research (SBIR) program and bodies such as the Defense Advanced Research Projects Agency (DARPA) lead the world in 'creating breakthrough technologies for national security' (see Bonvillian (2018); Kattel and Mazzucato (2018); Mazzucato (2011, 2014, 2015a, 2015b, 2018a, 2018b); Weiss (2014)). Over more than 60 years, it has played critical roles in developing the internet, wireless transmission advances, microelectromechanical systems, micro-processing advances, desktop computing, GPS technology, robotics, the

'revolution in military affairs' (e.g. drone technology), synthetic biology, computer simulation, etc (Bonvillian, 2018). These bodies and programs play active and directional roles to create new technologies in key areas of required sovereign capability: defence, communications, energy, health, etc.

Gunnar Eliasson (Eliasson, 2010) pursues a similar path of analysis of advanced procurement as industrial policy focusing on the much smaller example of Sweden's Gripen aircraft project. This is of significance for Australia and the issues considered here because it suggests that the benefits of active industrial and procurement policies can be achieved at different scales. His study calculated that the benefit to the Swedish economy of the Gripen project was at least 2.6 times the original development cost. These types of benefits can arise in large defence projects because a wide range of complex problems and challenges need to be addressed, leading to an array of drivers for new technology applications, positive spill overs and accelerated learning. This in turn leads the nation to benefit not once but twice:

1. From more cost-efficient delivery of the project, and
2. From capture of spill overs and opportunities for industry transformation these large, complex projects generate.

Eliasson however insists that such benefit capture for the nation in question depends upon local involvement in the design and product development phase, in which key technology and systems integration decisions are made. His focus is on defining and then measuring the economic value of technological spill overs, or the **spillover multiplier**. The system requires a demanding lead customer in turn requiring a number of problems to be solved, leading the project to become a broad-based technology driver across the economy. Hence the project produces not only the aircraft, but also a "cloud of spillovers". The demanding lead customer contributes their knowledge to the manufacturing process, and thereby helps lift the quality and extent of the technological spillover, representing a competitive advantage for the national economy.

Hence, there is joint production and a positive sum game, rather than a zero-sum game. Advanced public procurement is effective industrial policy utilising demand side drivers to create spill overs. Eliasson defines the spillover multiplier as "the ratio between the estimated social value net of opportunity costs created and the development investment that has created them".

The role of the customer(s) is foundational: "New products will never be better than the competence of customers to understand and to use them, and what they are willing to pay for" (Eliasson, 2010, pp. 2, 4-5, 43, passim). In effect, the lead customer is contributing their knowledge to the project - "The customer contribution to a joint product development is based on technical product and user knowledge on the part of the customer" (Eliasson, 2010, p. 14).

The Australian government can play a significant role in technological development as a purchaser of goods and services. We are far behind comparable countries in perfecting techniques of advanced procurement. The Australian Strategic Policy Institute have recently argued for the establishment of a formal partnership between the Department of Defence, defence industry, and Australian universities and the creation of an Australian DARPA. (Jennings & Clark, 2021).

3.6 East Asian industry policy

Japan, Taiwan and South Korea industrialised as the key plank of their modernisation and catch-up to the leading industrial nations to increase living standards, and to build sovereign industrial capacities, including for national defence or war-making. Sovereign capability and a high degree of self-sufficiency have been explicit in East Asian industry policy, in a way quite distinct from the earlier European industrialisers. In these national economies, public subsidies and robust institutional arrangements were and are used to set directions for industrial development. This has sought and achieved strategic advantage through upwards progression along the value chain and desired sectoral compositions, in line with long-term strategic visions. These visions have regarded as critical a moving set of required sovereign capabilities, the development of which has had a central place in policy (Amsden, 1989; Best, 1990; Brain, 1999; Stiglitz, 2002; Thurbon & Weiss, 2016; Wade, 1990, 1992).

4 Definitions in current use

This section surveys official and industry stakeholder definitions of sovereign capability in Australia, including the related concepts of Australian enterprise, Australian work, Australian Industry Content (AIC) and Australian industry. Official definitions outside of defence are scarce, and even within defence are applied inconsistently and used interchangeably.

The following describes the definitions and frameworks in operation in Australia currently. It describes the 'is' rather than the 'ought' of current policy. In sections 5 and 6 we outline principles and approaches that should underlay new and more adequate conceptions of sovereign capability particular to the nominated industry domains.

Because there is no consistent approach to the definition and measurement of sovereign capability, the definitions herein draw on many sources, including defence (Commonwealth of Australia, 2016a, 2016b, 2016c), the Australian Industry Participation Plan framework, various state-based industry participation policies, and others.

There is not a singular definition for Australian enterprise, work, industry content, or business that can be identified from the literature. The composite picture which emerges is of ad hoc, inconsistent arrangements with significant potential for underachievement of even modest aims. Definitions are minimalist and imprecision is frequent. For promoting economic development, the definitions of Australian enterprise and Australian work are a weak minimum. Current tensions relating to the submarine build in part relate to this. There is frequent slippage across the value chain, e.g., the expectation of manufacturing activity giving way to lower value assembly, lower involvement in smarter ends of the process, and so on.

Second, the definitions, imprecise as they are, solely concern dollar values, regardless of whether that dollar value is provided by, for example, laundry services or high-end new product development. Sovereign capability considerations appear to play little part. The focus is on the proportion of value we receive, rather than about what we need to be able to make or do. Quantitative, value-based targets are critical, and themselves need further development and stronger application.

However, sovereign capability should entail targeting the decisive points in the value chain, and especially in production, to decide what Australia must be able to make and do. Although some of the frameworks in the following overview mention capturing innovation, skills and new knowledge, the overall picture is one that gives less attention to these matters of new product or process development, than a simple aggregate dollar value. This passive non-directional approach contrasts with those addressed in the previous section, particularly the top-down Biden Executive Order on supply chains and sovereign capability, and the 'technology procurement' directions-setting approaches of the SBIR and DARPA in new product, technology and process development.

4.1 Australian enterprise

The definition used by the defence industry, which to our knowledge is the only explicit definition in use states that a business is Australian if it is:

- An Australian business entity that performs work in Australia with Australian-based employees and have an ABN, or
- A New Zealand business entity that performs work in New Zealand with New Zealand-based employees and have a New Zealand Business Number (NZBN), or
- A subsidiary of an overseas company based in Australia or New Zealand which meet the above criteria. (Clark, 2021)

This means that, for example, first and second tier suppliers linked to an overseas prime set up in Australia to compete with local suppliers would be considered an Australian enterprise, if the above conditions were met.

4.2 Australian work

No definition of Australian work could be found in the literature. In terms of employment, the *Fair Work Act 2009* (Cwth) defines an Australian employer as:

- A trading or financial corporation under the constitution, the Commonwealth itself or a Commonwealth authority, a body incorporated in a Territory, or carries on a business within Australia's exclusive economic zone and whose central management and control is in Australia, or is prescribed by the regulations

And an Australian employee as:

- A person whose primary place of work is in Australia; or who is employed by an Australian employer (whether the employee is located in Australia or elsewhere); or who is prescribed by the regulations.

4.3 Australian industry capability

Companies bidding for defence projects are required to submit an Australian Industry Capability (AIC) plan, outlining how it will maximise Australian industry involvement. The successful tenderer develops a subsequent AIC with the federal government. The capabilities sought by Defence include skills and knowledge, new technologies or innovations, the contribution to Australian company competitiveness, including access to global supply chains, technical data and intellectual property. A percentage local content target is not a requirement for the AIC, only an endeavour to maximise Australian involvement. In submitting its AIC plan, Naval Group defined Australian content based only on the value that has been added by Australian companies, and their workers, in Australia. This excludes any imported goods and services from Australian content calculation.

4.4 Australian industry content

Australian industry content (as a measurable proportion of the total project value accounted for by Australian goods and services) appears to have been relegated somewhat by Australian industry capability. Whereas industry content references the proportion of a contract spent on local suppliers and, as argued here, industry capability development is a critically important but distinct consideration. The evidence that in the absence of rigour and specificity, the shift to industry capability employed as an alternative (and not a complement) to measurable content, raises concerns. Key stakeholders across the naval shipbuilding program reveal the disparate

definitions and confusion surrounding Australian Industry Content as summarised in the quotes below.

> *Content refers to exactly that – how much of any given program contains content produced or sourced from Australian Defence Industry (Ziesing, 2017)*
>
> *The contractual framework promotes the establishment of a sustainable industry base in Australia with maximum opportunities for involvement in the delivery and sustainment of the Attack-class fleet without unduly compromising cost, capability or schedule (The Auditor-General, 2020).*
>
> *Rather than maximising Australian content in the finished submarines, the first of which is scheduled for delivery in 2032, Mr Davis said the contractor was obliged to develop the capabilities of the local industry.*
>
> *"I don't have the ability to prophesise on (content)," Mr Davis said. "What I will say is we have a commitment to Australian industry capability, and we will deliver on that."(The Australian, 2020)*

4.5 Australian sovereign capability

4.5.1 Defence

Across various defence related sources different opinions about sovereign capability have been identified from key stakeholders, including a shift over time from a concern on Australian content focused on production to 'access to' and 'control over' certain technologies, regardless of whether they are made in Australia. Contracts in naval shipbuilding specify an expectation of 60% of construction value and a moderate level of maintenance to be completed in Australia. In 2016, the official position was expressed as follows:

> *There are some capabilities that are so important to Australian Defence missions that they must be developed or supported by Australian industry because overseas sources do not provide the required security or assurances we need (Commonwealth of Australia, 2016a, p. 23).*

Naval Group in 2018 reflected the 2016 position of the federal government by stating:

> *[The] Commonwealth of Australia defines sovereignty as having enduring control over the operation and sustainment of the whole warship, including the ability to upkeep, update and upgrade the whole warship in Australia. The Australian Government Department of Defence 2018 Defence Industrial Capability Plan1 (s1.15 -1.17) provides further information on the intent and meaning of sovereignty (Naval Group, 2020, p. 2).*

However, by the release of the 2019 Sovereign Industrial Capability Priority Industry Plan, the definition of sovereign capability had been diluted, shifting focus from production capabilities to 'access to, or control over' for each priority.

> *The Australian Government will, on a case by case basis, make judgements as to the optimal level of access to, or control over for each priority. It does not automatically mean the priorities have to be designed, developed, manufactured or maintained in Australia, and for each priority, the level of sovereignty, may vary. Defence sovereignty is made up of many elements, and may include:*
>
> - *access to resident technical design capabilities (for example, to modify or upgrade systems);*

- *the ability to test and ensure that equipment is operationally ready for service or to be returned to service;*
- *access to, or control of, the facilities, technologies, and intellectual property underpinning our defence capability within Defence and Australian industry;*
- *access to allied capability that supports our warfighting advantage; and/or*
- *the ability to protect foreign-sourced, controlled technologies employed by the ADF (Commonwealth of Australia, 2019).*

This weaker position was reinforced with the 2020 Sovereign Industrial Capability Priorities:

> *In approaching development of the Priorities, we focused on a definition of sovereign industrial capability around access to, or control over, the essential skills, technology, intellectual property, financial resources and infrastructure within our defence industrial base as required (Commonwealth of Australia, 2020d).*

4.5.2 Other industries

Sovereign capability has for decades been almost completely absent from national policy considerations - with the exception of defence. From time to time, discussion arises on issues such as steelmaking capacity, security of fuel supplies, and recently, on Australia's capacity to produce medicines, PPE and medical devices. These episodic concerns, however, merely underline the extent to which sovereign capability has not been a feature of policy.

In domestic oil supplies stakeholders draw attention to the combination of Australia's dependency on oil imports, the diminution of its domestic refining capabilities, and dependency on MNCs as key vulnerabilities:

> *Three of the four major refineries in Australia are foreign owned.… It would be foolhardy to expect the refinery owners to act in any way other than to look after their own business interests (Blackburn, 2020)*

> *Even offshore fuel reserves are vulnerable because they involve long supply chains and depend on the availability of maritime assets. The shipping time from the west coast of the US will be up to 35 days. Tanker and insurance rates will be high, which will add to the pain if there is a conflict. And the US will likely have priority of access to all of the reserve, including Australia's portion, in the event of a conflict (Coyne & Crichton-Standish, 2020).*

> *However, the proposal has exposed one of the problems with Australia's national liquid fuel supply chains: a lack of bulk storage capacity (Coyne & Crichton-Standish, 2020).*

In cybersecurity, official sources and stakeholders also draw attention to Australia's current dependency on foreign owned entities:

> *Under the plan, the government would declare certain data sets as "sovereign", meaning they could only be hosted in Australia by an accredited Australian data centre across Australian networks and only accessed by the Australian government and service providers. (Sadler, 2020).*

Finally, as a catch all, the then industry minister expressed the watered down approach which we described in previous sections:

Where we can, the Government will invest in sovereign capability. Where we can't, we will contract with "like-minded" countries to ensure we have access to critical products and goods (The Hon Karen Andrews MP, 2020a)

4.6 Australian industry participation (AIP) plan

The requirement to develop an AIP applies to Commonwealth major procurements ($20 million or more), and to major projects generally worth $500 million or above. However, this does not involve mandated levels of Australian content in the plan. It should also be noted that no specific encouragement is given to transfer of IP or new product development. Thus, it is stated that "The key objective of the plan must be to ensure that Australian entities have full, fair and reasonable opportunity to bid for the supply of goods or services for the project". Once a Plan is approved, reports must be completed detailing participation by Australian entities in supply of goods and services, what goods and services have been acquired, dollar value of purchasing commitments over the reporting period, proportions going to Australian and non-Australian entities, details of the competitiveness and capabilities of Australian entities, and steps taken to meet Australian industry participation targets, amongst other things.

A scan of AIP Plan projects revealed estimated required expenditure on contestable goods and services in a project, but not a dollar value target for local industry participation.

4.7 State industry participation policies

Sub-national governments are parties to national AIP plans, and have developed policy frameworks geared to their circumstances. Overall, the survey below serves to underline limitations in the approach taken across Australia. The following summarises elements common to the policies of Queensland, New South Wales, Victoria and South Australia found in:

- *Queensland Industry Participations Policy Act 2011* (Qld); also *Local Industry Policy: A Fair Go for Local Industry: Guidelines* (Updated May 2011)
- *New South Wales Government Procurement: Small and Medium Enterprises Policy Framework* (Government of NSW, 2020)
- *Victorian Industry Participation Policy (VIPP) – Agency Guidelines* (Government of Victoria, 2017)
- *South Australian Industry Participation Policy* March 2018 (Government of South Australia, 2018).

These variously stipulate monetary thresholds of public and private projects for application of industry participation projects. Most apply a smaller monetary threshold where the project is regionally based. Thresholds start as low as $3 million for metropolitan projects ($1 million for a regional one) through to $10 million. Each state policy applies definitions of local goods and services (Australian or New Zealand) as under the national policy. Some provide annual reports to Parliament.

The Queensland policy emphasises infrastructure and resource projects. The New South Wales policy is pitched at SME participation through SME Opportunities Statements and development of SME Participation Plans.

The Victorian policy appears to have the most ambitious scope from the viewpoint of industry development, emphasising innovation, new product development, amongst other things. The South Australian policy also explicitly references industry development and dynamic facets beyond simply local content levels, to take in value chain development and a benefits realisation framework. The Queensland policy also refers to benefits from the policy in technology transfer and improved competitiveness of local industry. Victoria and South Australia both apply a weighting for local content and impacts on value chains, jobs, and capital expenditure in projects. No jurisdiction mandates minimum levels of local content.

5 Capabilities and vulnerabilities

Although the literature on sovereign capabilities is sparse, disruptions to supply chains resulting from the COVID-19 pandemic have generated discussion in Australia and internationally. This section analyses how supply chain disruptions in Australia impacted on the key domains of health, defence and space, energy, resources and infrastructure, science, communications and technology, and advanced manufacturing. It discusses what capabilities were revealed to be missing, and what capabilities were revealed to be important, as well as the strength of Australia's industrial base. An understanding of these capabilities is a key part of building sovereign capabilities in Australia. However, a more complete understanding of the gaps and weaknesses in Australia's capabilities in each of the industry domains can only properly be attained through a systematic, top-down analysis of the type being undertaken by the Biden Administration's 100-day review of critical U.S supply chains and associated larger and longer-term review. The focus must be on key capabilities, what we need to be able to make (industrial capabilities), and what we need to be able to do (operational capabilities). To some extent, this has already been undertaken in defence, however, a strong independent analysis within defence is also necessary to ensure that there is a clear focus and understanding on what we want to be able to make and do. A degree of dilution and slippage are evident.

Overall, the pandemic revealed Australia was lacking in capabilities across almost all the key domains. Supply chain disruptions in health, and energy were the most immediate and visible. In health, shortages in personal protective equipment (PPE) were forecast but did not arise – both due to the diminished impact of COVID-19 onshore, and the ability for Australian industry to refactor their production towards masks and hand sanitiser. In energy, Australia's acute fuel (in)security, and dependence on imports was revealed.

A vital point, consistent with the priority accorded to production capabilities as central to sovereign capability, is the indispensable role of advanced manufacturing, and of manufacturing generally. Manufacturing capabilities are those critical to sovereign goals of all the nominated industry domains: value-adding to Australian raw materials, securing sustainable energy supplies, developing advanced materials required in the future economy, producing critical inputs for other sectors including mining and energy, as well as manufacturing itself for pharmaceutical products and medical devices, together with sustainable energy technologies. Manufacturing is the key enabling sector for greater national sovereign capability.

5.1 Health

5.1.1 Sector characteristics

The healthcare supply chain consists of a complex network of diverse entities, across multiple countries with regulatory processes of differing strengths, resources, and incentives (Dai, Zaman, Padula, & Davidson, 2021). Building resilience into healthcare supply chains requires a mechanism to align divergent interests, promote data transparency, and share risk and rewards, to overcome excessive individual-level optimisation.

The supply chain for pharmaceutical products is also opaque. China produces many of the active ingredients used by drug manufacturers in other countries, sometimes from a single location (Coorey, 2020a), yet information about country of origin on medicines sold in Australia is not commonly available (Institute for Integrated Economic Research Australia, 2020).

The Australian medical devices industry can be characterised by a majority (about 54%) of SMEs, and about 35% global multinational companies or their subsidiaries (Commonwealth of Australia, 2016b).

The strength of Australia's capabilities in the health sector are mainly in the operational aspects of the quality of the health care system and hospitals, and pandemic management, compared to the relatively low levels of industrial capability. These research and operational capabilities might, with policy leadership, be used to help create a favourable environment for further domestic production, innovation, investment, and collaboration (Commonwealth of Australia, 2016b).

5.1.2 Discussion

In Australia, the disruption of global supply chains during the COVID-19 pandemic has led to a new focus on "independent" sovereign industrial capability (Commonwealth of Australia, 2020a), specifically the ability for Australian industry to produce the equipment and supplies required for the health response to the pandemic. The supply of PPE including hand sanitiser, and face masks, as well as ventilators was tested early in the pandemic when importing medical products became difficult. There was only one manufacturer of face masks in Australia at the beginning of the pandemic (and their annual production of masks was two million), and medical supply companies were unable to import key ingredients for the production of hand sanitiser.

The existing industrial base was able to refactor production processes to supply the Australian population. At the end of 2020, total production of surgical masks was estimated to be over 200 million across a number of businesses (Riley, 2020c). Wine and spirits manufacturers were able to refactor their production processes to meet increased demand for hand sanitiser as traditional manufacturers faced shortages of ethanol. Yet as the health management aspects of the pandemic have wound down in Australia, a slow vaccine rollout has hindered the return to normalcy. Australia remains dependent on foreign companies to develop and license production of vaccines.

In the European Union, four capabilities are identified as necessary to protect health sovereignty (Hackenbroich, Shapiro, & Varma, 2020). They are:

1. Early warning systems

Developing early warning systems allows a country to be more prepared for any future threats to health, including the spread of diseases. By being prepared earlier, the requisite measures necessary to protect public health can be taken proactively. Such systems can utilise innovative technological solutions, using big data, artificial intelligence (AI), and machine learning.

2. Supply chain resilience

An integral aspect of creating a sovereign health system is the resilience of the supply chain relied on by the health system. Global dependence on India and China for the provision of key medicines was exposed during the COVID-19 pandemic, as production and exports were suspended due to lockdowns in China, limiting the ability for Indian firms to manufacturer active pharmaceutical ingredients. The European Medicines Agency has commenced a taskforce to investigate supply chain resilience and is acting as a central coordinator to prevent and mitigate supply disruptions.

3. Medical research and development

The ability to develop both new treatments, and if necessary, new vaccines, provides a significant benefit for a nation's health security. Critical to this ability is a strong research and development culture in the medical sector, and a strong pharmaceutical industrial base.

4. Cyber security and technology

It is important to build and maintain secure data networks to ensure that contact tracing apps can keep track of infected patients and trace the spread of the virus. This links to issues around capabilities and vulnerabilities identified for the science, communications and technology sector, and has important considerations for the provision of telemedicine services.

5.1.3 Dependence

The pandemic revealed the world's reliance on China and India for key medicines. The Indian pharmaceutical sector supplies more than 50% of the total demand for vaccines, 40% of the demand of generics in the US, and 25% of all medicines in the UK (India Brand Equity Foundation, 2020). Australia is no exception to this dependence. More than 90% of all medicines consumed in Australia, totalling US$8 billion are imported, and Australian pharmaceutical businesses contributed 2% to the global pharmaceutical market in 2020 (Institute for Integrated Economic Research Australia, 2020), far above our population share.

Almost all PPE is imported, and there are no mandates for stockholding (Global Access Partners, 2020). Although the capability to produce surgical face masks was present in Australia before the pandemic, there was almost no capability for the production of N95 type masks, which offer superior protection from the spread of airborne diseases. Non-woven fibres, the key ingredient in the production of N95 type masks are exclusively manufactured in China. As a result, the Morrison government imported 54 million masks from overseas in March.

Table 3: Australia's dependencies in health capabilities

Capability	Australia's position
N95 face masks	In 2018, Australia exported $11.5M worth of N95 face masks, mostly to New Zealand, representing about 0.1% of global exports. Imports of N95 face masks totalled $228M mostly from China, representing almost 2% of global imports.
Pharmaceuticals	Australian pharmaceutical companies contributed about 2% to the global pharmaceutical market in 2020, exceeding its share of population.
Medical devices	In 2013, Australia's medical technologies market was worth US$6.81 billion, about 2 percent of the global market

5.1.4 Sovereign capability in Australia and our key gaps

Summing up, Australia has high operational capability in health (it can do many things through a strong healthcare services and research sector) but low industrial capability (it can make relatively few things). In pharmaceuticals Australia has lost productive capability. Some leading multinational companies (MNCs) and Australian-owned companies are present but with limited productive capacity and capability.

Health sovereign capability in Australia does not necessarily require an increase in the number of Australian-owned firms. However, it does require increased capability to ensure supply is possible at critical times when national interests come to the fore.

National government agreements with key multinationals for local production, and local research and development would increase the number of SMEs able to supply health equipment, medical devices, and pharmaceuticals. Some distilleries have reported that the government continued to rely on imported hand sanitiser after requesting that local supply needed to increase, leaving firms with excess supply (Bayens & Prendergast, 2020). The short-sighted focus on government purchasing at the lowest cost reduces the willingness for local manufacturing to refactor their processes in the future.

Although the supply chain for PPE was disrupted, Australian industry was able to successfully supply the requisite equipment for frontline health workers. It remains unclear whether supply would have sufficed were the pandemic to reach a critical stage in Australia. It was revealed that sovereign industrial capabilities in the production of medical devices and PPE are important, but it was not revealed whether Australian industry possess these capabilities at scale.

Thus, an analysis of the healthcare supply chain must be conducted, to determine which healthcare products are being made in Australia (and where), what the production capabilities are of each business, and the risks of shortages, and quality control issues. In the US production of PPE, each of these elements of the supply chain are considered trade secrets, and not made available to either government or health care professionals (Dai et al., 2021). Supply chains for PPE in Australia also lack transparency (Pournader, 2020). A lack of transparency makes planning difficult and increases the risk that even minor supply chain disruptions would significantly impact domestic production capacity because without publicly available data, both production capability, and the level of existing stockpiles remain unknown. Additionally, it is unclear where in the supply chain Australia is specifically vulnerable.

Other key elements of a Health sovereign capability are presented in Table 4.

Table 4: Required production and operational capabilities: Health

Production capabilities	Operational capabilities
A locally manufactured supply chain for medical devices, PPE and other essential supplies adequate for any perceived emergency in peace or war.	A national health system of high operational capability to independently sustain essential emergency, disaster and pandemic operations for a sustained period, in peace or war.
An Australian pharmaceuticals and drug manufacturing capability adequate to independently meet the nations needs in any foreseen contingency.	Capability to enable effective early warning systems, utilising big data/artificial intelligence to predict or pre-empt coming crises.

Building resilience in healthcare supply chains can help to mitigate the impact of future supply chain disruptions. This can be achieved by:

- Mandating publicly available data on the supply chain in the key areas of PPE, medical devices, drugs and pharmaceuticals,
- Requiring large manufacturers to undergo stress testing, to identify how quickly production can be ramped up. Firms which do not satisfactorily pass stress testing can

be obligated to rebalance their supply chains to maintain domestic capacity and reduce foreign dependency (Dai, Bai, & Anderson, 2020).
- Periodic review and surveillance of supply chains to identify vulnerabilities.
- A stocktake on university and hospital based pandemic and other health research.

Proactive national government policy position to negotiate with MNCs and local companies to ensure capacity and local capabilities, including levels of redundancy, are considered for designated areas in major population health areas, including pandemics and outbreaks, and other key generic medicines

5.2 Defence and space

5.2.1 Sector characteristics

The defence sector is unique in Australian industry being defined by a high level of government involvement, investment and planning. As a result, this sector exhibits fewer characteristics of a competitive market based on the principles of comparative advantage than the other sectors analysed in this report. Defence is the only industry sector in Australia deemed important enough to warrant a dedicated sectoral plan. The impact of government procurement is substantially higher than in other sectors, through the more than $200 billion planned defence investment (with $130 billion going into the shipbuilding program).[2]

Australian SMEs bid for work packages from large multinational and foreign-owned primes, with the winning business awarded a contract for work. Due to the foreign ownership of the primes, systems integration is a critical component for Australian businesses' abilities to compete for work against offshore suppliers, which are often favoured by primes. An understanding of how to upgrade and apply new technology to new and existing assets is vital to local industry participation generally, and to both sovereign operational (as well as industrial) capability. History is replete with instances in which a lack of access to and knowledge of the key controlling electronic systems in a military asset has compromised or even negated its operational effectiveness.

5.2.2 Discussion

The concept of sovereign capability in Australia has mostly been advanced through the defence industry, and the continuous shipbuilding program. Advocacy for the development of future frigates, and future submarines, has been put forward on the grounds of national security and sovereign capability. A significant body of work on sovereign industrial capabilities in Defence already exists, including:

- The 2016 Defence White Paper

[2] The next largest consolidated national government purchasing program is the Pharmaceutical Benefits Scheme, at around $12 billion per annum. However, this is not used as the basis for a sectoral program to promote local production, as in defence.

- The 2018 Defence Industrial Capability Plan which outlines the Government's intention to build and develop a defence industry base which is better able to meet defence capability requirements.
- The Sovereign Industrial Capability Assessment Framework, and the Sovereign Industrial Capability Priorities. Each of the priorities defined has an industry development policy, and an implementation policy.
- The 2020 Defence Strategic Update.

The Defence Industrial Capability Plan defines the Australian defence industry as "businesses with an Australian Businesses Number (ABN), and Australian-based industrial capabilities, that are providing or have the capacity to provide defence specific or dual-use goods or services in a supply chain that leads to the Australian Department of Defence or an international defence force" (Commonwealth of Australia, 2016a, p. 11; 2018c, p. 11), where "Australian-based industrial capabilities" refers to Australian ownership and presence, skills base, value-add work in Australia, and infrastructure.

The Sovereign Industrial Capability Assessment Framework defines a priority sovereign industrial capability as any capability which Australia assesses as strategically critical, and must therefore have access to, or control over, the essential skills, technology, intellectual property, financial resources, and infrastructure as and when required (Commonwealth of Australia, 2019) but also those capabilities in need of more dedicated monitoring, management, and support due to their industrial complexity, Government priority, or requirements across multiple capability programs.

A 2005 Defence Industrial Strategy white paper by the UK Government states that although it is important to control critical defence technologies, complete autonomy is only affordable by the US (HM Government, 2005). In the UK, the defence industry is defined by all defence suppliers that create value, employment, technology, or intellectual assets within the UK, regardless of their ownership. As such, the overarching concern in developing the industry is where the technology is created, where the skills and the intellectual property reside, where jobs are created and sustained, and where the investment is made.

The UK defence industry is highly connected into overseas supply chains. However, guarantees are included to provide technology access to ensure equipment can be adapted to meet national requirements over time. Significantly, national security priorities are identified, with industrial capabilities mapped to each level of national security. Those industrial capabilities which are linked with higher levels of national security policy require higher levels of sovereignty (see Table 5). For example, the UK's nuclear capabilities are all retained on shore by UK owned businesses.

Table 5: National security priorities mapped to industrial capabilities

National Security Priority	Sovereignty
Strategic Assurance	Retained onshore
Defence Capability	Assurance of continued and consistent equipment performance
Strategic Influence	No preclusion of global competition for projects in this sector.

The Parliament of Australia Senate Committee into Australian naval shipbuilding sovereign capability (Commonwealth of Australia, 2018b) highlights the disparate definitions of sovereign capabilities between government and industry. All stakeholders, including the government, supported the concept of building and maintaining a naval shipbuilding sovereign capability, with

the importance of Australian enterprise, work, and industry content through the entire process well recognised.

The CEO of Austal expressed a definition of sovereign capability on the comprehensive and encompassing end of the spectrum:

> *[Sovereign capability is] the ability to design, build, sustain, upgrade, and export Australian-built vessels, in Australian shipyards by Australian workers*

The importance of design, and Australian industry involvement in the design stage and subsequent systems integration is also articulated. The involvement in this stage is essential for Australian industry to be in the best position to undertake sustainment and repair of ships. The link between design and repair is persistently emphasised in the Senate Committee. This is consistent with the policy of the UK requiring access to technology, and leadership and self-determination in systems integration. However, Rear Admiral Greg Sammut has argued that it is not possible for Australia to have a sovereign design capability because:

> *[…] an indigenous design capability is a large and expensive capability that requires regular use to be of long-term benefit.*

This is not a credible position. The scale of Australia's build program certainly must be capable of sustaining such production functions and capabilities, which are foundational to long-term operational capabilities of these long-life assets. Small nations such as Sweden and Singapore (Tan, 2013, pp. 63-86) sustain design and systems capabilities in their national defence industries on smaller production scales than this. The scale of Australia's program not only makes development of selected design and systems integration economically viable; it also provides a position of strength in negotiating with foreign governments and the relevant MNCs, as well as potential to aggregate requirements across simultaneous naval shipbuilding projects.

While the definitions of sovereign capability differed with respect to where and how much Australian involvement was required, there was no clear or consistent understanding of what Australian involvement meant. The Collins Class submarine, labelled as an "Australian Build" used companies, deemed to be local, who sourced industry content from offshore (Commonwealth of Australia, 2018b). There were also situations where components were manufactured overseas, shipped to Australia, and assembled, and assessed as being an Australian industrial capability (*Future of Australia's naval shipbuilding industry*, 2017, p. 27). Significantly, no minimum percentage of Australian industry involvement is mandated for defence Primes, despite a 60 percent threshold required to be considered locally built (*Future of Australia's naval shipbuilding industry*, 2017).

5.2.3 Dependence

Across the defence and space industry, there is often less publicly available data on dependency on other countries due to issues of national security, and commercial in confidence arrangements. As at 2021, Australia's military expenditure totalled about 2.1% of national GDP, totalling US$27.5 billion, only slightly lower than the world average of 2.4%. As a proportion of global military expenditure, Australia contributes about 1.4%.

Australia's attempts at building a defence sovereign capability has been on the production side, but this has been interpreted narrowly. Effective industrial capability requires capture of activities such as design and systems integration, both upstream and downstream of

construction. There has been a noticeable slippage in presentation by officials of Australian local content to emphasise 'metal bashing' at the expense of these upstream and downstream activities in the case of shipbuilding, and in other cases to speak of 'access to' or 'control over' key items, rather than onshore production of them. The focus being on industrial capabilities rather than operational capabilities such as design, systems integration, and imports of modular components. As expressed throughout the Senate Committee on the future of Australia's naval shipbuilding industry, industry and other stakeholders recognise and desire the capabilities to design, sustain, and upgrade Australian navy vessels, yet this is considered to be too expensive to develop locally.

In a general capability sense, Australia depends on the US as a strategic ally. With a relatively small population, and a weak industrial base, Australia has continued to rely on foreign powers, whether the British pre-WW1 or the US post-WW2 for maintaining security. These arrangements have resulted in the continued support of US strategic ambitions, however, the rise of China as an economic competitor to the US while also being a significant trading partner for Australia, means that the interests of the US and Australia have become more dynamic and face new challenges. The US is and will remain the leader in systems development, and is innovative in cyber warfare, artificial intelligence, autonomous systems, hypersonic, direct energy weapons, and constellations of satellites (Beazley, 2018) meaning Australia will remain dependent on the US relationship to incorporate new defence technologies into Australian defence equipment.

5.2.4 Sovereign capability in Australia and our key gaps

To sum up the current position, Australia's defence sector has medium-high operational capabilities, alongside low-medium productive capabilities - a position that may improve through the application of advanced procurement and sectoral policies, although there appears pressure to dilute these policy aims. However, the policy has attempted to ensure MNCs which operate as lead customers in the value chain commit to a level of local production and help support development of the capabilities of locally-owned SMEs. This sets defence apart from the other industry domains.

Whilst a more robust concept of sovereign capability applies in this sector than anywhere else in Australia, it remains rather partial and incomplete, with results not always meeting expectations, and with official signs of dilution of original aims and lowered expectations. A review is needed to identify what we want to make and be able to do, to re-evaluate where the nation sits with respect to the original aims of the Defence White Paper and associated documents, and to take quick and determined corrective action.

Additionally, sovereign capability in defence relates to Australia's ability to defend itself and advance our interests in the region. Situations could arise where, during an extended period of conflict, Australia is unable to source products, knowledge, or expertise from overseas suppliers or governments. A critical component of Australia's sovereign defence capability is therefore on the operational side, with sustainment, upgrade, repair, and replacement of defence materiel, including surface ships and submarines, land vehicles, and RAAF aircraft key aspects of sovereign capabilities. These in turn require the productive capabilities already present in the Australian defence industry to also incorporate aspects of design and systems integration. Recently, a F-35A engine was repaired in Australia, by an Australian-owned business, marking the first occasion of this repair activity outside of the US (Kuper, 2020).

Australia's history of the past half century or more attests to the link between external dependency and the nation's ability to deploy in conflicts. Over successive conflicts, and across

multiple foreign dependencies, Australia's operational capabilities have been constrained. This includes inability to use the French Mirage fighter in Vietnam due to the French government's reluctance to provide sustainment support, the Swedish government's denial of ammunition resupply for the Carl Gustaf anti-tank weapon, during the same conflict, our failure to purchase an aircraft carrier from the UK government due to their reprioritisation of requirements during the Falklands conflict, which also lead to problems with Australia's sustainment of its Oberon class submarines, which had been purchased off the shelf from the UK.

Ultimately, developing sustainment capabilities, and through-life support activities should be a focus to enhance and build local capabilities across the sector, including additional production capabilities (which include design and systems integration) over time. Government should also be more assertive in signing contracts with defence primes, setting stronger ex-ante contract performance targets, to ensure that critical aspects of defence projects such as design processes and systems integration are offered the same importance as construction projects.

Other areas of combined industrial and operational sovereign capability for the Australian defence and space industries include:

- General Capability. An Australia which can defend itself independently without dependence upon allies, overseas suppliers, third parties or foreign governments
- C4ISR/operations. An ADF with command, control, communications, computers, intelligence, surveillance, recognisance, and combat systems which can be independently operated, maintained, repaired, upgraded and sustained
- Space. An understanding of the design and engineering requirement to build and replace all aircraft, satellites, and space vehicles.

5.3 Energy, resources, and infrastructure

5.3.1 Sector characteristics

Most of the largest energy generators in Australia are either partially or fully Australian-owned. More broadly, however, large parts of the transmission and distribution systems are foreign-owned. Australia's endowment of fossil fuels has resulted in an electricity generation mix dominated by black and brown coal, although this domination has declined recently with the advent of improved solar and wind technologies (owing to geological conditions in Australia favourable to the generation of renewable energy). The energy network, comprising transmission towers, substations, poles and wires, and pipes are owned and managed by a mix of private and government-owned organisations (Energy Networks Australia, 2019). The electricity network is completely privately owned in Victoria and South Australia, and completely government owned in Tasmania, Western Australia, Northern Territory, and Queensland. The gas distribution providers across Australia are all privately owned, except in the Australian Capital Territory.

In the resources sector, large multinational businesses are dominant. This together with policy arrangements favourable to these businesses, but unfavourable to the national interest, has allowed the Australian resources industry to regress towards a predominantly export oriented, low value-add, extractive industry, alongside strong overseas repatriation of its revenues.

5.3.2 Discussion

Sovereign capability in this sector encompasses the following:

- Fuel storage capacity (number of days stored fuel, and the location of the storage)
- On-shore refinery capabilities
- On-shore minerals processing capabilities, and the capacity to value-add to Australia's abundant raw materials.

A sovereign fuel supply is an amount of fuel, in reserve, which can ensure that future shocks to fuel supply do not significantly impact domestic production, or availability.

The International Energy Agency, of which Australia is a member, obliges countries who have signed up to maintain a stockpile of 90 days' worth of crude oil. Australia has consistently failed to meet this obligation (Blackburn, 2020). While immediate fuel security was under pressure during the COVID-19 pandemic, as the price of oil collapsed, it is the issue of ongoing fuel security which severely impacts Australia's national resilience. The number of refineries in Australia has reduced from seven to four between 2012 and 2015, and three of the four are foreign-owned. It is unclear whether or not the Australian government would be able to force foreign-owned companies to refine crude oil during times of crisis if it were against their best interest to do so (Blackburn, 2020).

A national oil reserve proposed by the Energy Minister Angus Taylor on 22 April 2020 involved the purchase of about 3 million barrels, equivalent to 30 days of national supply. This supply, however, has been stored in the US and would take two to three weeks to arrive in Australia if required. This represents a significant risk to the sovereignty of Australia's fuel reserves, as supply could be cut off. This arrangement was put in place for 10 years. Offshore fuel reserves are vulnerable, because they involve long supply chains and depend on the availability of maritime assets to deliver the fuel on-shore. Shipping from the west coast of the US to Australia could take as many as 35 days. If a conflict arose such that Australia needed immediate access to this fuel, then the lead time until it would be accessible would be problematic. Additionally, the US would likely have priority of access to all of the reserve, including Australia's portion, in the event of a conflict (Coyne & Crichton-Standish, 2020). The arrangement to store a portion of Australia's liquid fuel supply overseas has resulted from the lack of bulk storage infrastructure and capacity on shore (Coyne & Crichton-Standish, 2020).

Moving now to broader issues in Australia's resources and energy sectors, Australian policy works against greater national self-reliance and sovereign capability in several ways, with respect to its mineral and energy resource endowments. The first point to grasp is that the transition to zero carbon energy is central to possibilities for Australia's reindustrialisation, as well as leading to the enhancement of sovereign capability in key materials and energy sources. Zero carbon energy itself contains the benefit of improved energy self-sufficiency. Detailed analysis by Garnaut (2019) and Beyond Zero Emissions (2020), has demonstrated not only that Australia can decarbonise without net economic loss but also become a net exporter of energy to the world.

Australia has a portfolio of world-significant deposits of high value resources and energy sources. These resources apply to both the energy inputs required by decarbonisation of the economy, and to new production opportunities requiring new materials (e.g., titanium and advanced composites for medical devices). The bulk of Australia's titanium production is low value titanium oxide for export, with reliance on imports of value-added products made from the raw material.

Similarly, Australia has the world's third-largest known reserves of lithium required for lithium ion batteries. However, Australia overwhelmingly exports spodumene (the least processed and

lowest value form of lithium), receiving less than one percent of the potential value of the lithium battery value chain through its exports of the ore (Australian Trade and Investment Commission, 2018; Beyond Zero Emissions, 2020). Australia exports about $1.13bn worth of spodumene, exporting more than all other countries, yet claims nothing further along the value chain. Globally, $156bn worth of batteries was exported in 2017. Further, while demand grows for aluminium as a light weight and environmentally friendly material, Australia largely exports unprocessed bauxite at around $42 per tonne, compared to smelted aluminium, at around $2700 per tonne (Ibid). Iron ore was sold for about $220 per tonne in 2021, compared to the about $850 for one tonne of steel (Trading Economics, 2021).

Analysis and modelling from the US Biden Executive Order on supply chains makes analogous and instructive comparisons concerning the importing of rare earths into the US, and their strategic, economy wide significance. It finds that "approximately $613 million in US consumption of rare earth elements unlocks approximately $496 billion in economic activity in essential civilian sectors including petroleum refining, electromedical device manufacturing, automotive manufacturing, and search, detection, and aeronautical instrument manufacturing" (The White House, 2021, pp. 167-168). In Australia, the position is reversed, with significant exports of unprocessed rare earth elements at low prices, to the benefit of other countries who undertake value-adding activities. The above passage from the Biden executive order indicates the orders of magnitude of the missed opportunity for Australia.

Similar points apply to other materials of the future such as graphene, silicon and others. Current national policy favours their raw extraction over their development as national value chains, by a combination of commission and omission. More traditional materials such as steel and aluminium also warrant revived secondary processing strategies, particularly to underpin new products and processes required in the green economy.

Australia has lost much secondary resource processing capacity over the past two decades, during which there has been little policy focus on processing ores. That is, Australia has not replaced processing capacity in traditional ores and has not developed processing capacity in new high-growth materials. Foreign investment dominates the resources and energy sectors, with encouragement to export of unprocessed raw material and energy sources in clear preference to a national policy promoting processing and value-adding through incentives and imposed conditions (joint venture, local content, and industry participation agreements).

The dimensions of this complete policy failure have very recently been underlined by the Biden Executive Order. It deals with battery storage technologies as vital to future energy security, and with lithium and other minerals as critical to battery storage technologies. Considering Australia, it states:

> *Despite significant natural resource endowments of battery-related materials, Australia has not yet developed a broader ecosystem for advanced batteries. Australian state governments have introduced incentives to support the development of local battery industries, but the Australian Government has not yet developed a comprehensive national strategy to develop a domestic battery industry.*
>
> *Australia has an abundance of key commodities needed to produce advanced batteries, such as lithium, nickel, vanadium, graphite, manganese, and alumina. These commodities require processing, however, before becoming battery materials. Australia currently has no Class 1 chemicals or battery precursors. Australia has no cell manufacturing, but it does have an active battery pack assembly industry. Australia only recycles two percent of its lithium-ion*

batteries, and its recycling processes typically disassemble and homogenize materials for export to places like Korea, which have developed battery recycling capabilities.

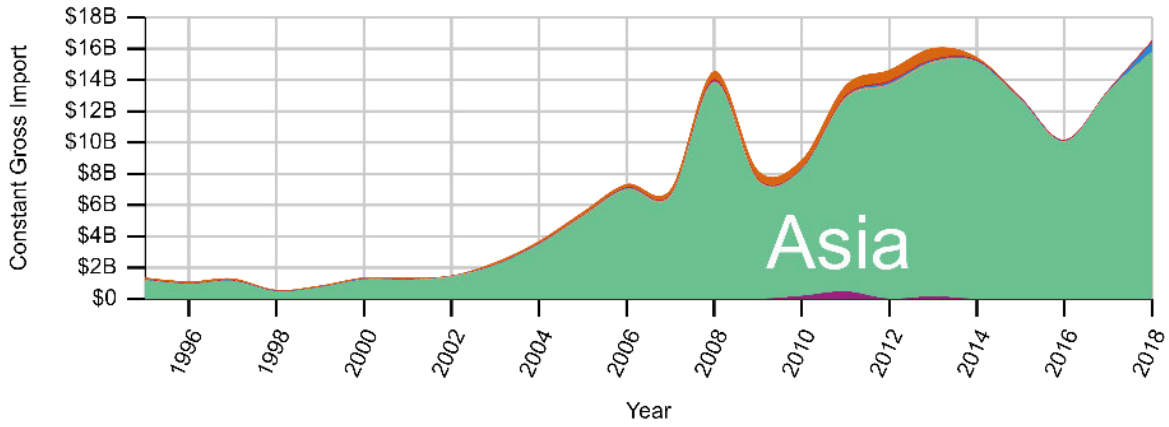
Australia currently lacks battery-specific initiatives at the national level" (The White House, 2021, pp. 123-124)

Reshoring of secondary processing to Australia is favoured by decarbonisation imperatives, requiring ores processing to take place close to the energy source (Garnaut, 2019, pp. 110,112). Australia's endowments of both renewable energy and key minerals, particularly aluminium and iron ore and steel, favour Australia as a site for energy-intensive low carbon manufacturing. As energy generation becomes more renewable, the value proposition for onshore processing of minerals increases, because of the higher transportation costs of renewable energy (Garnaut, 2019). Other raw materials processing and value-adding opportunities for Australia opened by zero-emissions energy include lithium (for battery production), copper, nickel, titanium, cobalt and vanadium (Garnaut, 2019).

5.3.3 Dependence

Australia currently imports about 90% of its liquid fuels, which are imported and refined by on-shore refineries on a 'just in time' basis (Coorey, 2020b). On-shore refineries have reduced in number with three of the remaining four foreign-owned. The BP refinery in Kwinana in South Fremantle has since been converted to a fuel import terminal (Laidlaw, 2020). As the number of on-shore refineries decreases, Australian industry becomes more dependent on imports of refined product. In 2018, Australia imported US$17.5 billion worth of refined petroleum oils, an increase over the US$12.5 billion imported in 2008 (see Figure 5-1).

Figure 5-1: Australian gross imports of refined petroleum oils



Source: The Growth Lab at Harvard University (2019)

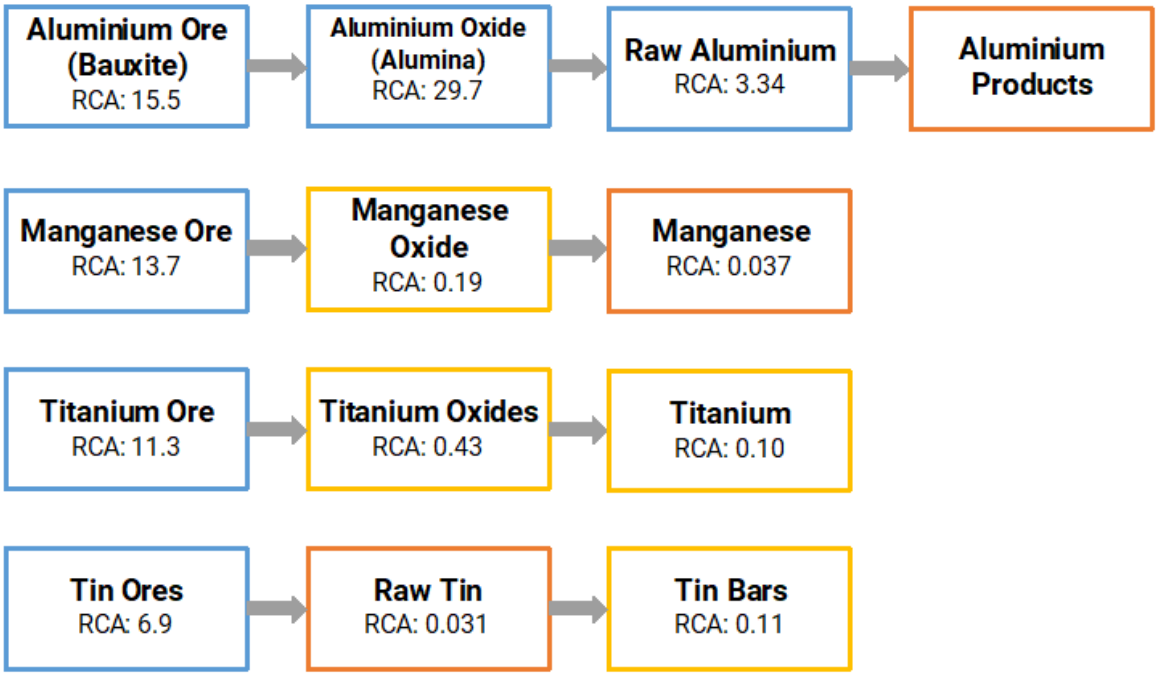
Total onshore bulk capacity for crude oil is also not sufficient to meet Australia's obligations under the International Energy Association, resulting in 30 days of crude oil supply being stored in the US. Australia is dependent on access to this crude oil supply for continued operation of the Australian Defence Force, and broader Australian industry.

An example of Australia's dependence on offshore processing for elaborate transformation of raw materials can be seen in the mining industry, and the imbalance between Australia's exports of raw minerals relative to the exports of processed minerals and transformed minerals.

Figure 5-2 shows Australia's extractive capabilities in mining aluminium, manganese, titanium, and tin ores, and highlights how capabilities to convert the raw minerals into metal products are limited. Products in blue are those in which Australia has strong sovereign capabilities, while those in yellow are products in which capabilities exist but are limited. Products in orange are those in which Australian industry maintain almost no capabilities.

It is important to recognise, however, that Australia's low capabilities in secondary processing of its abundant raw materials is a feature of the past two decades particularly. In many instances it reflects the loss of previous secondary processing and value-adding capability for traditional metals, and the loss of installed capacity. In other cases, it reflects the policy favouring offshore processing of Australian minerals and the consequent failure to develop secondary processing in new materials, many of which are being demanded by high growth industries internationally. The reduced secondary processing capability results from national policy decisions. It does not necessarily reflect an insuperable technological (or other) barrier to future onshore processing.

Figure 5-2: Raw minerals processing capabilities in Australia



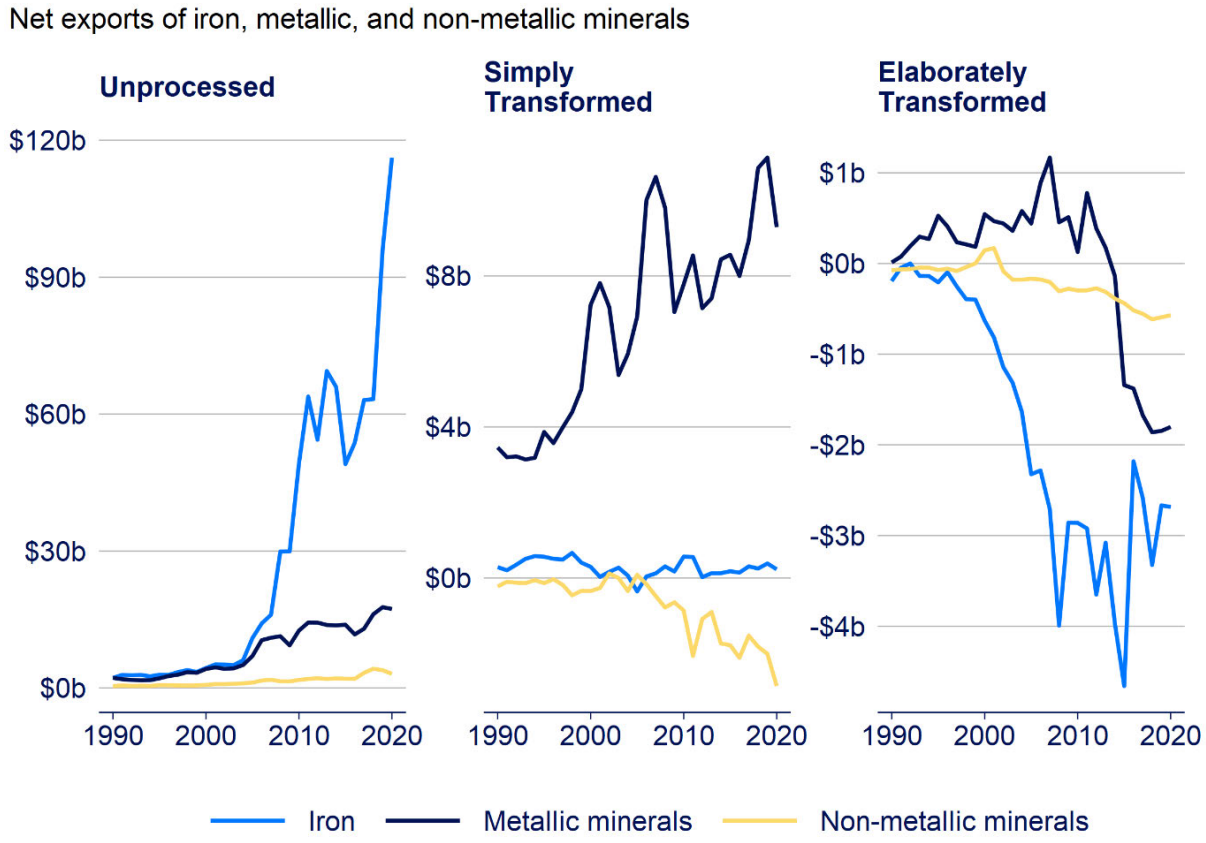
Note, RCA = Revealed comparative advantage.
Adapted from Gamble, Rampersad, Spoehr, and Hordacre (2020).

Australia is also dependent on other countries for minerals which are not present in Australia, such as chromium and tungsten. China refines 60 percent of the world's lithium and 80 percent of the world's cobalt, both of which are core inputs into the production of high-capacity rechargeable batteries (The White House, 2021).

Indicative of Australia's dependence on offshore minerals processing is the trade deficit between unprocessed metals, simply transformed metal products, and elaborately transformed metal products (see Figure 5-3). Australian industry is a dominant global provider of unprocessed ores, especially iron ore, and maintains a trade surplus in the production of simply

transformed metallic minerals, and close to parity for iron products and non-metallic mineral products. Australia is losing out when it comes to elaborately transformed manufactures. Although net exports were near parity at the start of the 1990s, dependence on imports of elaborately transformed manufactures, especially of iron products, has increased significantly since.

Figure 5-3: Trade balance by manufacturing status of iron metallic and non-metallic minerals



Note changes to values on the Y-axis.

5.3.4 Sovereign capability in Australia and our key gaps

To sum up, in energy, resources and infrastructure, Australia has largely regressed to be an exporter of unprocessed raw materials for offshore value-adding, alongside maximum import reliance for upstream plant, equipment and technology, and domination by overseas owned and revenue repatriating MNCs. For energy and resources, the policy has been the mirror opposite of the stated policy goals in defence. Here low productive capability directly reduces operational capability and sovereign capability. It has reduced our energy self-sufficiency and ability to make goods of strategic importance in the event of major supply chain disruption.

Building sovereign capability in this sector does not require Australia to own all ports, rails, roads, oil refineries, or mining companies. However, increased public ownership of some key assets, including electricity generation and distribution networks, and greater regulation, would improve public accountability over these sectors. Lower electricity and gas prices could be delivered to households and industries by requiring all onshore energy generation infrastructure to be managed and controlled locally, with high rates of Australian industry supply chain participation and research, development, and intellectual property. The extent to which the predominant

private ownership of Australia's electricity infrastructure creates impediments to achieving these outcomes, requires us to be open to the possible resumption of public ownership of parts of the electricity network as a last resort, noting that this would also provide a significant spillover benefit to the manufacturing sector. Diversification of the sources used to generate energy in Australia – away from coal and gas and towards renewable sources such as solar, wind, and green hydro - would also greatly benefit Australia's sovereignty, as it is difficult for other countries to impede access to them. Such a transition is a necessary condition for Australia becoming a global superpower in the generation of green energy. Australia has a comparative advantage over other countries in the input into renewable energy generation, from significant land availability to build solar panels and wind farms, to favourable weather conditions. Parallel to these advantages, Australia is endowed with the third largest natural reserve of spodumene, the precursor to lithium, which should enable Australian industry to also have a comparative advantage in the development of lithium-ion batteries for energy storage.

As argued elsewhere in this analysis, the same point applies across a vast and important range of Australia's ores, metals and other raw materials that are required for sovereign capability in all the domains under discussion. Building secondary processing capabilities is critical: it is inconceivable that Australia could remain an exporter of unprocessed ores and an advanced manufacturer using those ores as imported metals and advanced materials for the purpose of onshore production of high-value medical devices, batteries, or other elaborately transformed manufactures.

Building sufficient on-shore storage capacity for crude oil reserves remains a key gap in Australia's sovereign energy capabilities, by reducing dependence on other countries for storage, and ensuring that the demand for on-shore refining remains.

Some key components of Australian sovereign capability include:

- Sufficient local gas, oil and refined fuel production and storage capability to ensure Australia can, without reliance upon imports, maintain its economic and military capabilities throughout the course of any perceived emergency, crisis, or war.
- Ability to provide the nation's own steel and essential metals, and energy needs, utilising the required transition to carbon-free power sources.
- Ensuring power, water and essential services are supported by national systems which are locally designed, built and maintained and which are either Australian-owned or if foreign-owned, able to be controlled securely and independently during any emergency or conflict.
- Ensuring sovereign control over vital infrastructure (ports, airports, rail and essential infrastructure) adequate to ensure its secure unimpeded operation at all times.

5.4 Science, communications, and technology

5.4.1 Sector characteristics

The science, communications, and technology (SCT) sector encompasses a broad range of capabilities, new technologies, and factors which can be considered as enabling across the other key domains, including the strength of the university sector, STEM skills in the workforce, and research and development capabilities including research translation. Australia has a strong university sector with seven local universities ranked in the top 100 (QS Quacquarelli Symonds, 2021). The CSIRO is also an internationally-recognised science and technology

research body. However, the CSIRO'S position with respect translation of research to production, together with that of other research organisations, is on the whole, very weak.

The SCT sector includes technologies relevant for sovereign capability including disruptive technologies, cloud capabilities, cyber security, digital health, education technology, and mining software and specialised technology. Cybersecurity has the advantage in Australia of being considered as part of the broader defence sector. As such, a cyber security strategy has been developed, outlining the key capabilities required to enforce and ensure Australia's cyber security (Commonwealth of Australia, 2020c). The Australian cyber security industry is segmented into five groups including SMEs, major consultancy firms, international technology integrators, mid-tier firms, and defence-related firms (including the primes). The government and defence sector contributes almost 30 percent of total revenue of cyber security firms (Commonwealth of Australia, 2020b).

Within communication, ownership and operation of communication infrastructure, such as 5G, and the strength of this infrastructure to remain operational is a critical consideration. This sector was one of the earliest examples of the government service outsourcing wave commencing about 25 years ago. Australia was in the vanguard of much of this, which often locked in governments to single vendors to deliver cost reductions, but often at the expense of developing local capability, and at the expense of SMEs.

5.4.2 Discussion

When the Australian government developed the COVIDSafe application to assist with contact tracing efforts, concerns were raised about both the security of the Australian data stored on US servers, as well as the ability for the US government to coerce Amazon to provide them with the data (Sadler, 2020). The US government has authority under legislation to access data held by American owned companies operating in other jurisdictions. An agreement with the US government, if finalised, would allow "service providers in Australia and the United States to respond to lawful orders from the other country without fear of running afoul of restrictions on disclosure, and thus provide more access for both countries to providers holding electronic evidence that is crucial in today's investigations and prosecutions" (US Attorney General William Barr & Minister for Home Affairs Peter Dutton, 2019). Given Australia's early positions on excluding Huawei from development of 5G infrastructure, and our strong foreign interference stance involving China, the apparent inconsistency with the US is notable.

Developing a sovereign cloud capability would, as then Minister for Government Services Stuart Robert declared, restrict foreign companies such as Amazon and Microsoft from handling government datasets. Additionally, under a plan for sovereign cloud capabilities, data sets could be declared by the government as "sovereign", meaning that could only be hosted in Australia, by an accredited Australian data centre, across Australian networks, and only accessed by the Australian government and service providers (The Hon Stuart Robert MP, 2020).

Whitham, Liebowitz, and Penten (2020) identify sovereign capabilities in artificial intelligence (AI) as providing a national advantage in future conflicts through decision making superiority. The key components of sovereign capabilities in AI include:

- Confidence that imported AI capabilities (if imported into defence technology), will not be restricted by other nations.
- The data used to generate AI results in decisions which reflect the views of the Australian population, and the ethics of the Australian military.

This sovereign capability is built on a skilled workforce and requires continued investment into STEM skills at the school level, research, and development, and AI engineering skills. A critical aspect of a sovereign AI capability is sovereign national datasets. These datasets must be collected and curated, and shared to all sectors involved in building the national capability (Whitham et al., 2020).

Research by AustCyber has found that a four-week disruption to the nation's digital infrastructure that results from a significant cyber security incident would cost the economy $30 billion or about 1.5 percent of GDP, with the direct loss of 163,000 jobs (Riley, 2020a). These magnitudes of economic loss would be larger than the cost of Australia's recent involvement in overseas deployments to Afghanistan. Mitigating the risk requires building sovereign cyber capability and reducing the nation's reliance on offshore technology providers and investment in local industry. The increasing prevalence of cyber-attacks underscores the importance of this capability.

A sovereign capability taskforce has been established in New South Wales to assist local tech companies to access government contracts, with the aim to build sovereign capability, via industry development. The objectives of this taskforce are to define sovereign procurement, and to define what is an SME (Riley, 2020b).

The Australian government has stated in justification of its decisions, that foreign ownership of the 5G communications network would not be allowed. It has banned Huawei from operating in Australia, justified by concerns that additional security measures would have to be applied to Huawei equipment to make it safe, and the fear that ultimate control of the network would reside in Beijing (Hartcher, 2021). Further, the 5G network is essential for the continued operation of critical infrastructure:

> *The sewerage pump stops working. Clean water doesn't come to you. You can imagine the social implications of that. Or the public transport network doesn't work. Or electric cars that are self-driving don't work. And that has implications for society, implications for the economy. (Hartcher, 2021)*

5.4.3 Dependence

Australia relies on foreign cloud service providers Amazon (via Amazon Web Services) and Microsoft for hosting of sometimes sensitive government datasets, despite the presence of local companies with such capabilities. Outsourced IT and cloud services, especially if located offshore are subject to both lawful and covert data collection and are subject to foreign laws, which can allow a foreign government to access any stored data.

Modern research laboratories are extremely reliant on technology. They depend on access to high-performance computers and data stores, just as much as physical workshops and labs. Australian researchers and businesses depend on access to supercomputers to solve computational problems standard computers cannot handle (Commonwealth of Australia, 2018a). The importance of semiconductor devices for providing this technology cannot be understated, they are used in almost all technology-based products, as well as household items. The US semiconductor industry accounts for about 12 percent of global production, though semiconductor fabrication is highly concentrated in Asia. Like the rest of the world, Australia relies on Taiwan, South Korea, and China for the fabrication of semiconductors.

Although Australia has an internationally regarded university sector, with seven universities ranked in the top 100 globally, university funding is strongly tied to full-fee paying

international students. Significant reductions in revenue due to past and current border closures resulting from the COVID-19 pandemic required universities to reduce staff by at least 17,300 in 2020 (Universities Australia, 2021). This dependency of research on revenues from international and other fee paying students diminishes Australia's potential sovereign capability by compromising resources for cutting-edge strategic research.

The CSIRO is internationally-regarded as a science and technology research organisation, but not as a developmental one. It is an exemplar of a strong research body in a policy vacuum and a weak industrial ecosystem. Australians are rightly proud of the CSIRO WLAN contribution to the development of Wi-Fi. They are less aware that Wi-Fi illustrates Australian failure as much as success. Such individual research 'national champions' as were involved in Wi-Fi are nowhere near the equal of the industrial national champions of, say, Europe. There, mission-oriented research helps feed development of new products and innovations at the technological frontier through positive networks including advanced public procurement. This builds these nations' sovereign capability. In contrast, the CSIRO held patents and sought (initially unsuccessfully) to sell the technology to offshore technology majors. At no point does it appear any alternative route had been considered that involved further local development and public investment, nor the establishment of an onshore company to localise future benefits. The CSIRO does not involve itself in making things; the closest it comes is early-stage commercialisation.

Australia is a net importer of ICT services, and computer, electronic, and optical products. In 2018, net imports of ICT services into Australia totalled 4.4 billion US dollars up from 2.9 billion in 2008 (The Growth Lab at Harvard University, 2019) and the trade balance in computer, electronic and optical industry was -23 billion US dollars in 2019 (OECD, 2021d).

5.4.4 Sovereign capability in Australia and our key gaps

Recognition of the importance of sovereign capability in SCT remains the first step to ensuring resilient supply chains, and the security of existing infrastructure. Sovereign cloud services are significant, as foreign cloud services can limit the safety and security of the data stored on them. This is also relevant for developing an AI and machine learning capability in Australia. As AI technology makes decisions based on the data it has been trained on, an imported AI technology, trained by data collected overseas, may not make the kinds of decisions which reflect the views of the Australian population, or the ethics of the Australian military (Whitham et al., 2020). To that end, the collection, collation, and storage, of Australian data on Australian cloud services will enable the development of a stronger local AI capability, with no restrictions on its access imposed by other nations.

Technologies for climate monitoring are another important aspect for Australia's sovereign capability in SCT. Climate change has and will continue to have material impacts on food security, infrastructure stability, and population health. Maintaining an awareness of the likely impacts of climate change, as well as developing technologies to assist in reducing these impacts through mitigation and adaption capabilities is necessary to ensure Australia's sovereignty in these areas. Digital skills and digital competencies are critical for capabilities across all five industry domains.

Other areas of combined operational and industrial sovereign capabilities for the Australian SCT sector include:

- An authoritative and recognised institution capable of maximising chances of local development and production of research and invention in Australia, beyond commercialisation and sale offshore, as occurred in Wi-Fi

- Strong and independent universities and research centres of excellence capable of ensuring Australia is not dependent on any other nation or third party for sustainment of key national capabilities in defence and aerospace, artificial intelligence, cyber security, 5G communications, biological, chemical, food and water security and any other area deemed essential to the national interest.
- Science capabilities adequate to ensure a lead role in emerging technologies such as AI, machine learning, autonomous systems to ensure that any requirement of Australia for support and services on other nations does not compromise its technological sovereignty.
- A resilient local cyber security capability to ensure that Australian assets, businesses and infrastructure is not incapacitated by cyberattack which is not dependent upon foreign owned or controlled interests.

5.5 Advanced manufacturing

5.5.1 Sector characteristics

Advanced manufacturing refers to firms and clusters of firms competing on the basis of unique knowledge and expertise, and the application of new knowledge (innovation) to achieve efficiencies in their own production processes, and often to address environmental or social challenges. They are often SMEs specialising in short-run production of high-value, high-complexity goods, enhanced by strong service-based offerings. They often utilise new materials and new digital production processes. In recent years, a notable shift has occurred in opinion and sentiment amongst economists toward deliberate and directional industrial policies and interventions to support the development of knowledge intensive manufacturing. A strong element in this reevaluation of interventionist policies has been recognition of the centrality of manufacturing to large scale challenges such as climate change, population ageing, and economic and social inequality (Aiginger & Rodrik, 2020; Rodrik, 2014).

Advanced manufacturing is an enabling sector across the other key sectors analysed. Therefore, capabilities in advanced manufacturing can be utilised to improve capabilities in other sectors and enhance sovereign industrial and operational capability. The manufacturing sector in Australia consists largely of SMEs, some of which are integrated into the defence supply chain. With the closure of the automotive industry in Australia, there is no longer this large industry vertical for manufacturing businesses to be integrated into. Within the manufacturing sector, value chain linkages are likely to be distant and import dependent, and key value chain capabilities absent.

5.5.2 Discussion

Sovereign capabilities in advanced manufacturing are enabling capabilities across the other key sectors analysed. Through the provision of inputs into other domains identified (though not to the exclusion of others), new industry verticals can be created.

In a speech at the National Press Club, then Industry Minister Karen Andrews said that "complete self-sufficiency should not be our goal" in manufacturing (Riley, 2020c). Instead, the nation must identify areas of potential supply chain fragility and focus on reducing dependence on foreign supply chains for essential items needed in a crisis, while continuing to support sectors in which Australian industry has a comparative advantage. Areas of national priority

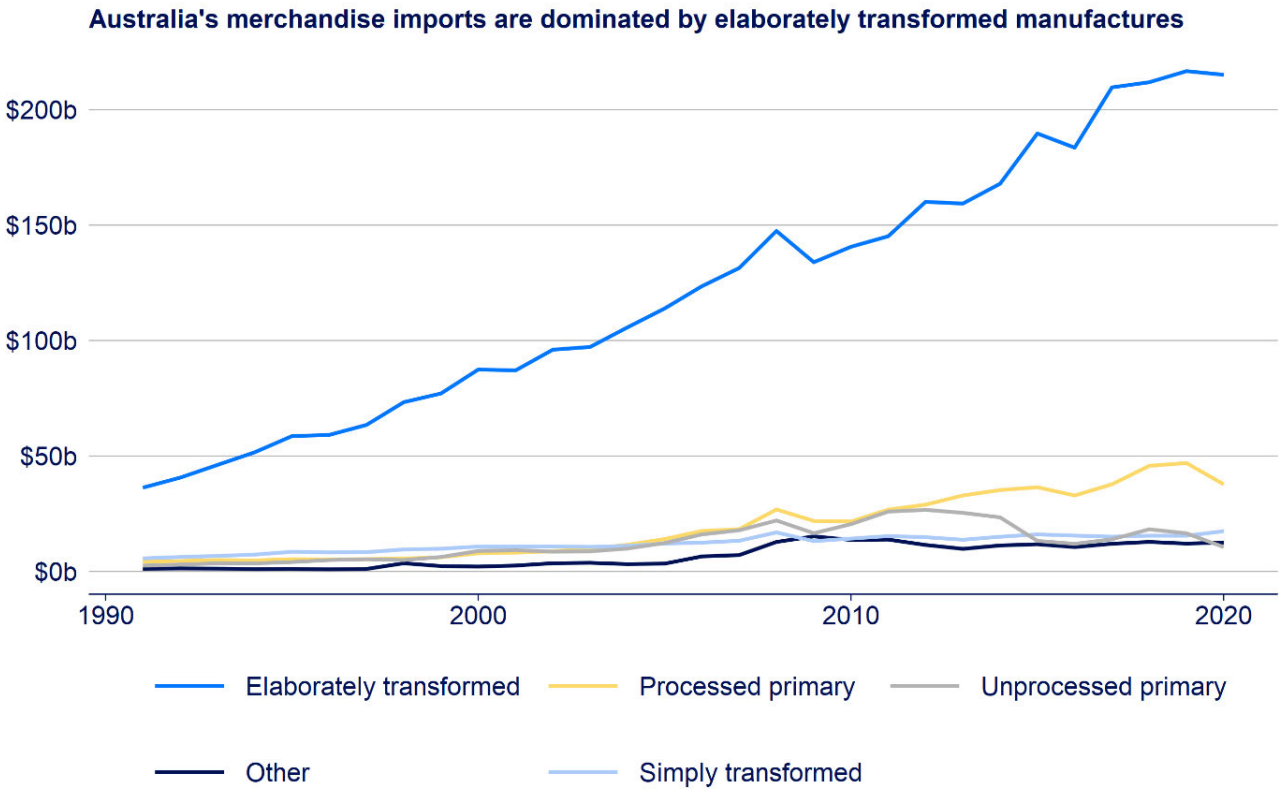
identified were pharmaceuticals and medical technologies, defence, energy technology, the space industry, and waste and recycling.

An advanced manufacturer in today's Australia is less likely than previously to be part of a large-scale vertically integrated onshore supply chain. Automotive had been Australia's most complex onshore value chain. Today that description is probably best applied to the naval defence sector. But typically today's Australian advanced manufacturer is likely to be an SME operating in highly specialised niches and highly integrated into global value chains rather than onshore outwardly oriented value chains. Australian ownership is predominant in this sector, in contrast to the others surveyed.

5.5.3 Dependence

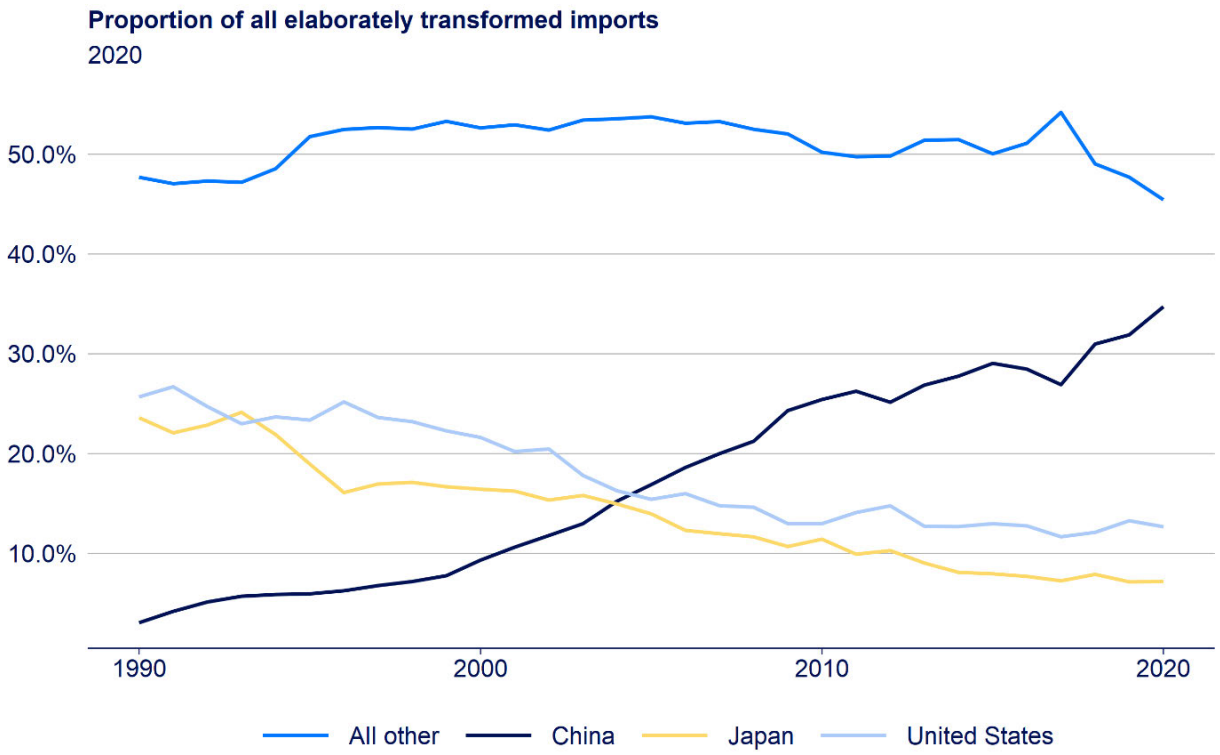
Data from the Department of Foreign Affairs and Trade shows how dependent Australia is on imports of elaborately transformed manufactures. In 2020, about 75% of all imports into Australia were of this category. Figure 5-4 shows the increase in reliance on China for elaborately transformed manufactures, increases from below 5% in 1990, to over 35% in 2020.

Figure 5-4: Australian imports by transformation level classification



Source: DFAT (2021)

Figure 5-5: Import dependence



Source: DFAT (2021)

5.5.4 Sovereign capability in Australia and our key gaps

Overall Australian advanced manufacturing is characterised by low productive capabilities which also translate to low operational capabilities and low self-sufficiency, resulting frequently in inability to make goods of strategic importance in the event of major supply chain disruption. This has additional significance because manufacturing inputs are of strategic importance across all the other industry domains assessed. The sector primarily comprises locally-owned SMEs that today lack the connections to large-scale complex industry verticals, of the type formerly provided by the automotive sector.

Each priority sovereign capability industry domain is manufacturing-dependent: health (devices and pharmaceuticals), defence and space, energy, resources and infrastructure, science, communications and technology, and advanced manufacturing itself. A key element of the vision for Australian advanced manufacturing is to build onshore verticals within which Australian manufacturers supply key equipment, services and technologies to the priority sovereign capability industry domains, including greater secondary processing of raw materials. At present these sectors are heavily dependent on high-value manufactured inputs sourced as imports.

Australia's potential for reindustrialisation and growth in advanced manufacturing is favoured by three large-scale trends:

Decarbonisation	Digital Technologies	Value Chain Resilience	Strategic Change in the Indo Pacific
Australia's vast supplies of renewable energy and metals and materials demanded by the low emissions future economy, together with the requirement for production and processing close to the renewable power source.	The rise of digital technologies and new business models that allow competitive flexible short- to medium-run production. Being small is no longer a competitive disadvantage.	The increased awareness of global value chain vulnerability and recognition that certain basic capabilities need to be held and maintained onshore.	The changing international dynamic between China and the US has renewed focus on industrial resilience and sovereign capability in all domains discussed.

Industry 4.0 is the cornerstone of advanced manufacturing. Building a workforce with sufficient skills in and knowledge of industry 4.0 practices and concepts is an essential part of building sovereignty in advanced manufacturing. Industry 4.0 technologies utilise the internet of things (IoT), device interconnectedness, and big data to improve manufacturing processes, allowing small manufacturers to produce more efficiently, compete on quality, and fill niche market sectors. Integral to this aspect of industry 4.0 is access to reliable and high-speed broadband or fixed-wireless internet. In Germany and elsewhere digital innovation and adoption are accorded a national strategic status lacking in Australia.

These manufacturing capabilities are critical to the ability to be proficient systems integrators, of such weight and importance to capturing value chain opportunities and sovereign capabilities in complex large scale major projects in defence, mining resources and energy, and elsewhere.

The opportunity is to develop national scale sectoral programs and policies to identify and address gaps and decisive points for the creation of coherent and highly competent onshore industry verticals linking advanced manufacturing to the other priority industry domains, and thereby enhancing sovereign capability.

This would require the Commonwealth to adopt a far more active industrial policy position somewhat at odds with its previous and current positions. It would require, as a starting point, value chain mapping comparing current production competences against overall requirements, assessing gaps, identifying decisive points with the highest positive impacts on economic development and sovereign capability, and addressing key requirements in a targeted manner.

This would be complemented by an active approach to MNCs and foreign direct investment (FDI) mirroring the abovementioned priorities. This would see national government setting agreements with MNCs for local production and local value chain development. In critical areas such as medical supplies and pharmaceuticals, it would see clear guarantees of production and local supply.

Some key components of Australian sovereign capability include:

- A nation capable of independently manufacturing its own essential needs.

- Closely integrated university and industry collaboration linked to our industrial strengths including mining, resources and energy, medical devices, food and agriculture, defence and aerospace, autonomous systems, communications, transport and infrastructure.
- An ability to design and produce complex knowledge intensive intermediate and final products for domestic and international markets, together with value-adding and secondary processing of Australia's world-significant portfolio of high-value raw materials, metals and ores.

6 Expanding the concept of sovereign capability

6.1 Introduction

Across the key sectors analysed, there is a consistent recognition that sovereign capabilities are important. Unfortunately, there is not a consensus on a definition of either 'sovereign', or 'capabilities'. The defence sector has made the most progress in this area, identifying that sovereign capabilities depend upon a level of local manufacturing, but also include sovereignty over supply chains, workforce, design, and business ownership. However, even here there has been slippage of sovereign capability somewhat away from an earlier emphasis on manufacturing and production capabilities to operational 'access to' or 'control over' certain technologies or capabilities. Clarity is also missing from definitions of Australian enterprise, Australian work, and Australian industry. With no clear definition of these concepts, achieving greater manufacturing self-sufficiency in areas of need will remain difficult. The very absence of these fundamental definitions denotes the absence of policy. This provides the space for ongoing avoidance of these issues by the national government and a continuing void in leadership alongside opportunity for noncompliance and underperformance by industrial majors in large scale projects. At present, government, industry, and other stakeholders talk at length about Australia's sovereign capabilities, but there is often only a set of general ideas as to what this means.

Some useful perspectives on definitions of Australian 'made', 'product' and 'grown' as applied to food products, has been delivered through the Australian Made campaign, though these definitions also suffer from the types of imprecision and definitional slippage observed elsewhere. Noting these definitions were not strategic or concerned with sovereign capability. That is, they did not focus on what Australia needs to be able to make and do to achieve defined national goals. The history of consumer 'Buy Australian' campaigns is given at Appendix A.

The focus here, as in the previous section, is on strategic sovereign capability criteria focussed first and foremost on answering the questions of what we need to be able to make, and what we need to be able to do, to achieve the nation's interests in key nominated areas such as defence, population health, energy and essential raw materials, food, environment and climate risks, and essential production capabilities?

Good answers to these questions must have regard to issues such as:

- Existing industry structures for each industry domain
- The specific character of international value chains pertaining to each domain
- The differing significance of foreign ownership in each sector or domain
- What constitutes the decisive points along the specific value chain, control of which will lead to the greatest degree of:
    - Industrial sovereignty (what we need to be able to make)
    - Operational sovereignty (what we need to be able to do).

This underlines the point that a strong strategy and policy for sovereign capability would apply guiding principles, together with consistent, robust and transparent quantitative and qualitative measures of effort and performance against ex-ante benchmarks. At the same time, these would be applied having regard to objective variations in contexts and sectors. The variations observable today are due to ad-hockery and imprecision. The variations are not presently the outcome of a robust framework applied to materially different sectors.

To assist, and to advance the analysis of the previous section, we present a typology of degrees and distinct types of sovereign capability.

6.2 Sovereign capability types

Sovereign capabilities can be placed onto a spectrum based on where in the production process Australian inputs are used, like the food labelling scheme. Inputs do not refer only to physical products or the direct production process, but also to other upstream and downstream aspects of direct production (such as design, systems integration, through-life support and technology upgrades, service enhancements of the product), together with other aspects such as industrial processing, business ownership, and labour inputs. The more these operations are Australian, the higher the degree of sovereign capability in that industry. On one end of the spectrum a final product is wholly imported from another country and there is a likely high degree of dependency on the producer(s) from that country for IP and services relevant to operation, through-life support, and technology upgrades. On the other end of the spectrum, a product is designed in Australia, by Australian engineers, and built using Australian intermediate inputs which themselves have been processed in Australia, by Australian workers, at Australian owned businesses. Between these two extremes, varying proportions of Australian products might be used, or some manufacturing might occur offshore, businesses might not be Australian owned, and skilled foreign labour may be used. Table 6 summarises this spectrum of sovereign capability.

The definition of "Australian" is vitally important in this framework. A design could be completely imported, or developed across multiple businesses with different ownership, or entirely within one Australian owned business. Thus, each of the components of sovereign capability should also be assessed on a spectrum, where the higher proportion of Australian involvement in an activity, the more the sovereign capability.

Table 6: The spectrum of sovereign capability

Increasing sovereignty	Australian Design	Systems Integration in Australia	Australian Industry Content	Australian Enterprise	Australian Work
Complete autonomy	The product is designed in Australia	Systems integration is performed onshore to local specifications and involving local expertise. [NB: it is unlikely that an Australian company would/could originate principal systems themselves].	The product is manufactured in Australia using only Australian made inputs	All businesses in the supply chain are Australian owned	All businesses employ only local workers
Substantially transformed in Australia	x	Systems integration largely performed offshore and imported to Australia	Substantial transformation of inputs involves Australian manufacturing. Inputs may or may not be imported	The business may or may not be Australian owned	The business may or may not hire only local workers
Simply transformed in Australia	x	x	Simple transformation of inputs involves Australian manufacturing. Inputs may or may not be imported	The business may or may not be Australian owned	The businesses may or may not hire only local workers
Assembled in Australia	x	x	Assembly may involve some Australian manufacturing	An Australian owned business may assemble the product	The business may hire local workers
Imported	x	x	x	An Australian owned business may import the product	The business importing may hire local workers
Resource extraction	x	x	Likely to be confined to operations and services, some local applied R&D	MNCs dominate; Australian support service companies	The business will employ local operations and maintenance workers

Most critically, "Australian" matters from the perspective of the quantity and quality of production from within the sector in Australia. There is also a differential interplay of this issue with ownership structures and global value chains, that is material for considerations of sovereign capability.

In Defence, sovereign capability takes account of the fact that it is a complex value chain with key required capabilities in foreign-owned multinational lead customers. Sovereign capability here means ensuring those MNCs base a high minimum of their production here, together with commitments to share IP and collaborate across the local value chain and with research providers, etc.

Because around 80 percent of the resources sector is foreign owned, and because policy has allowed the sector to regress away from onshore processing towards the cheapest possible extraction of the least processed ores and energy sources, foreign ownership has a different

significance from that in defence. This structure allows resource MNCs to repatriate profits abroad on extraction with minimal onshore processing. Upstream of the mines' operations, local content in mine construction and technologies was seen to have fallen from well over 50 percent at the start of the last decade's mining boom in 2003, to well below 50 percent by around 2011. This decline had several causes, amongst which was the shift in the balance of resources expansion toward large offshore LNG projects with very low local content (Gregory & Sheehan, 2011). Key systems technologies, together with plant and equipment, are increasingly imported as modules. Australian content is concentrated on more basic construction, operations and labour.

This policy failure has locked in, for the time being, high dependency and low sovereign capability with regard to key mineral and energy resources. The structure favours early-stage extraction for overseas markets over domestic value-adding. Consequences include Australia's having some of the world's highest domestic gas prices, whilst being the world's largest gas exporter. More generally, we have seen that this model has reduced capacity for secondary processing (with further consequences for dependency in areas like medical devices and new energy technologies), and reduced sovereign capability in strategic materials and energy.

One set of conclusions in response to such unacceptable outcomes concerns the requirement for national policy leadership, including sectoral policies and strategies, a preparedness to negotiate and set conditions with MNCs for access to Australian resources, markets and major projects, the setting of strong ex-ante goals and benchmarks, and adopting sector-wide and portfolio approaches to future development of projects, so that through aggregation of demand, scale is built that permits greater possibilities for value-adding and new product and technology development.

6.2.1 Subsidiary issues in sovereign capability types

Sovereign capability depends on a range of interacting factors whose relative significance will vary as between sectors, places and times. However, this analysis maintains that the level and quality of sovereign capability fundamentally depends upon the presence or absence of defined production capabilities and the presence or absence of national policy explicitly and strategically prioritising the achievement of sovereign capability and distinct capabilities.

But as sovereign capability exhibits just such complexities, involving many factors operating simultaneously, it is here useful to consider issues of foreign dependence outside the determinative sphere of production itself. We have seen that loose and highly permissive definitions currently apply in major projects to the definition of an Australian company, industry content, and Australian work. Questions arising typically include:

- Is an import, say of a submarine engine, that is manufactured offshore but assembled onshore, an Australian product?
- Can an overseas prime, or tier one or tier two supplier, be an Australian enterprise and, if so, how?
- Can it be considered an Australian enterprise if its board is offshore?
- Can it be considered an Australian enterprise if its Australian management is from offshore?
- What about issues of IP ownership and use, connections to local universities and SMEs, and offshore revenue repatriation?

Again, production and policy provide the key criteria. An imported engine is only Australian content to the value of its assembly and integration into the vessel, which will be far lower than if manufactured here. An overseas prime, or tier one or tier two supplier should be considered an Australian enterprise for a given project, depending on its level and qualitative commitment (coinciding with the decisive points in the value chain) to local production (including pre-production design, systems integration, through-life support, etc). This will also be the case where the company's board is wholly foreign, and where management also has a high foreign content, again, provided the commitment to Australian production is high. Issues such as connectivity to local universities and commitments to Australian SME development are extremely important and have as their basis, whether or not the company is committed to Australian production.

Policy bears critically upon these issues, both during contract negotiation (ex-ante requirements of the government as final customer), contract compliance and enforcement, and providing shape and direction to the project over time. For example, the army land vehicles program involves importation of overseas manufactured products for assembly and through-life support in Australia. Because the through-life support component is so vast (about three times the value of the initial purchase cost), local content is significant even though local manufacture is absent. However, this very feature provides opportunity for policy and government to commence and increase Australian manufacture of the vehicles over time, if so minded. Similarly, policy together with the development of local production over time, can shift the balance toward Australian senior management, local access to or ownership of new IP, and other benefits to sovereignty.

6.3 Sovereign capability issues by sector

Given the above considerations, it is essential to ask in each of the nominated industry domains:

- What does the best option for increased sovereign capability look like?
- What are the decisive points for focus and capture?

These questions can only be answered ultimately through the type of top-down detailed investigation being undertaken in the US under the Presidential Executive Order. Through such investigation the decisive points can be identified. In the interim, the following observations seek to advance a practical vision of Australian sovereignty by sector and points for action towards the goal.

6.3.1 Health

A practical vision for securing Australia's health sovereignty is:

- ***A strong national health system****:* able to independently sustain essential emergency, disaster, and pandemic operations for a sustained period, in times of peace or war.
- ***Essential manufacturing capabilities****:* A local supply chain for medical devices, personal protective equipment, and other essential supplies adequate for any perceived emergency in peace or war. Pharmaceuticals and drug manufacturing capabilities to independently meet the nations needs in any (foreseen) contingency.
- ***National strategy for production capabilities****:* proactive national government agreements with key multinationals for local production and local supply chain development, sector and product development plans, expanding the cohort of SMEs able to supply health equipment, medical devices, and pharmaceuticals, and analysis of the health care supply chain, what production capabilities exist, what are the critical gaps

against critical risks, what products are made currently and where, areas of import dependency of concern (including single source of supply), capacity and redundancy issues, quality, etc.

- ***Early warning systems**:* operational capability to enable effective early warning systems, utilising big data and artificial intelligence to predict or pre-empt coming crises
- ***Transparency**:* mandate publicly available data on the supply chain in the key areas of PPE, medical devices, drugs, and pharmaceuticals.
- ***Resilience**:* build resilience in healthcare supply chains to mitigate the impact of future supply chain disruptions by requiring large manufacturers to undergo stress testing, undertaking periodic reviews and surveillance of supply chains to identify vulnerabilities, and taking stocktake on university and hospital based pandemic and other health research.
- ***Review**:* utilise information on critical gaps revealed in a mandated overall top-down Executive Order-like supply chain analysis.

6.3.2 Defence and space

A practical vision for securing Australia's defence and space sovereignty is:

- ***Defence materiel capabilities**:* to be able to build, design, systems-integrate, operate, sustain, upgrade, repair, and replace defence materiel, including surface ships and submarines, land vehicles, and aircraft, including during extended conflict, without excessive reliance on overseas suppliers or governments.
- ***C4ISR/operations***: an ADF with command, control, communications, computers, intelligence, surveillance, recognisance, and combat systems which can be independently operated, maintained, repaired, upgraded and sustained.
- ***Design and engineering:*** An understanding of the design and engineering requirement to build and replace all aircraft, satellites and space vehicles.
- ***Domestic support:*** Increase and develop domestic sustainment and though-life support activities.
- ***Production capabilities:*** Incrementally develop local production capabilities in areas of underdevelopment e.g., land vehicles.
- ***Contracts:*** Ensure ex-ante strong contractual provisions with Primes and others to strengthen design, systems integration and 'system of systems' integration, other critical technologies and extending production capabilities and Australian value chain participation over time.
- ***Review:*** utilise information on critical gaps revealed in a mandated an overall top-down Executive Order-like supply chain analysis.

6.3.3 Energy, resources and infrastructure

A practical vision for securing Australia's energy, resources and infrastructure sovereignty is:

- ***Oil, gas, fuel capabilities:*** Sufficient local gas, oil and refined fuel production and storage capability to ensure Australia can, without reliance upon imports, maintain its economic and military capabilities throughout the course of any perceived emergency, crisis, or war. This can be achieved through gas reservation policy, and by meeting mandated minimum oil and petroleum reserves through additional and repurposed storage infrastructure.

- ***Zero-carbon generation:*** achieve energy sovereignty and self-sufficiency through orderly planned transition to zero-carbon energy, utilising wind, solar and other renewables, together with new storage technology, ensured through an official national strategy.
- ***Carbon-free transition:*** utilise the carbon-free transition (requiring raw materials processing close to energy source) to achieve greater supply chain stability and materials sovereignty, including:
    - Self-sufficiency in steel, aluminium and other basic metals using energy-intensive carbon-free production
    - Acquire secondary processing capabilities in new materials such as titanium and other advanced composites for medical devices, lithium for battery technology, copper, nickel, cobalt, and vanadium, etc.
    - Ensure this through official national strategy for secondary processing, value-adding and value chain development
    - Strategy to include negotiated agreements with MNCs and large Australian firms, including sector plans, conditional FDI with value-adding and joint venture provisions, etc.
- ***Essential services:*** Ensure power, water and essential services are supported by systems which are locally designed, built, and maintained and which are either Australian-owned or if foreign-owned, able to be controlled securely and independently during any emergency or conflict, including protection against cyber-attacks.
- ***Infrastructure:*** ensure sovereign control over vital infrastructure (ports, airports, rail and essential Infrastructure) adequate to ensure its secure unimpeded operation at all times, including protection against cyber-attacks.
- ***Review:*** utilise information on critical gaps revealed in a mandated overall top-down Executive Order-like supply chain analysis.

6.3.4 Science, communications and technology

A practical vision for securing Australia's science, communications and technology sovereignty is:

- ***Ecosystem:*** An ecosystem and critical competences that protect Australia's requirements and interests against bad actors.
- ***Mission-oriented institutions:*** Mission-oriented institutions leading a science, research and technology ecosystem focussed on achievement of the specific outcomes required for the development of sovereign capabilities
    - These are the technological aspects of the broader decisive points that require maximum focus to achieve the objective
    - Strong capabilities in AI and machine learning
    - Includes cyber-protection
    - This includes being an authoritative and recognised institution capable of maximising chances of local development and production of research and invention in Australia, beyond commercialisation and sale offshore, as occurred in Wi-Fi.
- ***Workforce:*** sustained and continuous investment in schools, TAFEs, universities, and research institutions to build a highly capable workforce, and accelerate the safe diffusion and uptake of key enabling technologies through the identified domains. Investment in research institutions with a strong industry outreach and collaboration ethos to bridge the gap between research and translation.

- ***Protection:*** development and increased use of Australian sovereign cloud capabilities to store sensitive data, a highly protected and secure national communications infrastructure, including 5G roll out, and the National Broadband Network.
- ***Review:*** utilise information on critical gaps revealed in a mandated overall tops-down Executive Order-like supply chain analysis.

6.3.5 Advanced manufacturing

A practical vision for securing Australia's advanced manufacturing sovereignty is:

- ***Technologies:*** become internationally competitive in the adoption and development of selected national cost effective, competitive world class advanced manufacturing technologies, autonomous systems, and machine learning to produce value-added and refined products for local and overseas markets, through a national manufacturing strategy, including for digitalisation and Industry 4.0.
- ***Industry verticals:*** Build strong onshore industry verticals with a focus on developing specific manufacturing production capabilities linked to the sovereign capability domains: health (devices and pharmaceuticals), defence and space, energy, resources and infrastructure, science, communications and technology, and advanced manufacturing itself. Ensure this through a national manufacturing strategy with priority sectors and industry verticals, with links to decarbonisation and a secondary processing strategy. This also includes approaches to MNCs and FDI aligned to the strategy aimed at agreed levels of local production of required goods and services.
- ***Gap identification:*** Comprehensively identify and address gaps and decisive points for the creation of coherent and highly competent onshore industry verticals, starting with value chain mapping identifying decisive points with the highest positive impacts on economic development and sovereign capability, and addressing key requirements in a targeted manner.
- ***Review:*** utilise information on critical gaps revealed in a mandated an overall top-down Executive Order-like supply chain analysis.

7 Facts on competitiveness and capabilities

Section 5 provided detail on the current position concerning sovereign capability in the five industry domains ('the is'). Section 6 considered key decisive points and actions for attaining the levels and nature of sovereign capability that would be feasible, as well as necessary, for Australia at the level of sectors or industry verticals. The intent was to present a practical vision of 'the ought'. This section addresses the general underlying horizontal capabilities and issues of competitiveness, the presence or absence of which either supports or undermines sovereign capability aims and goals. It assesses Australia's current position against relevant international performance.

The relative economic competitiveness of nations has long been the focus of policymakers seeking to improve overall economic performance and the performance of particular strategic sectors in particular. Australia's ranking amongst other global powers in key indicators of manufacturing competitiveness and skills is varied.

Perhaps one of the most important measures of competitiveness available to policymakers currently is the relative level of 'economic complexity' of nations and regions. This measure differs substantially from standard measures such as productivity and GDP. Economic complexity measures the productive knowledge present in a region based on the products that it exports with comparative advantage (Hidalgo & Hausmann, 2009). It is strongly correlated with both current levels of GDP, as well as future GDP growth. Economic complexity reveals two insights relevant for a nation's industry development. First, it identifies the existing capabilities present in a region by the products it exports. Second, it identifies the similarities or otherwise of capabilities required to develop products and quantifies the extent that these capabilities are present in a region.

Economic complexity analysis uses global export data to rank both countries and products based on their level of complexity[3]. Two measures of complexity are calculated: Economic Complexity Index (ECI) which ranks the complexity of countries, and Product Complexity Index (PCI) which ranks the complexity of products. The relationship between the diversity of a region's exports, the ubiquity of products exported globally, and their respective complexity can be explained with an analogy to Scrabble. In the analogy, capabilities are represented by letters, and products are represented by words. Players (countries) with rarer letters (capabilities) can play both more words (products) and combine their letters in unique ways to produce words worth more points.

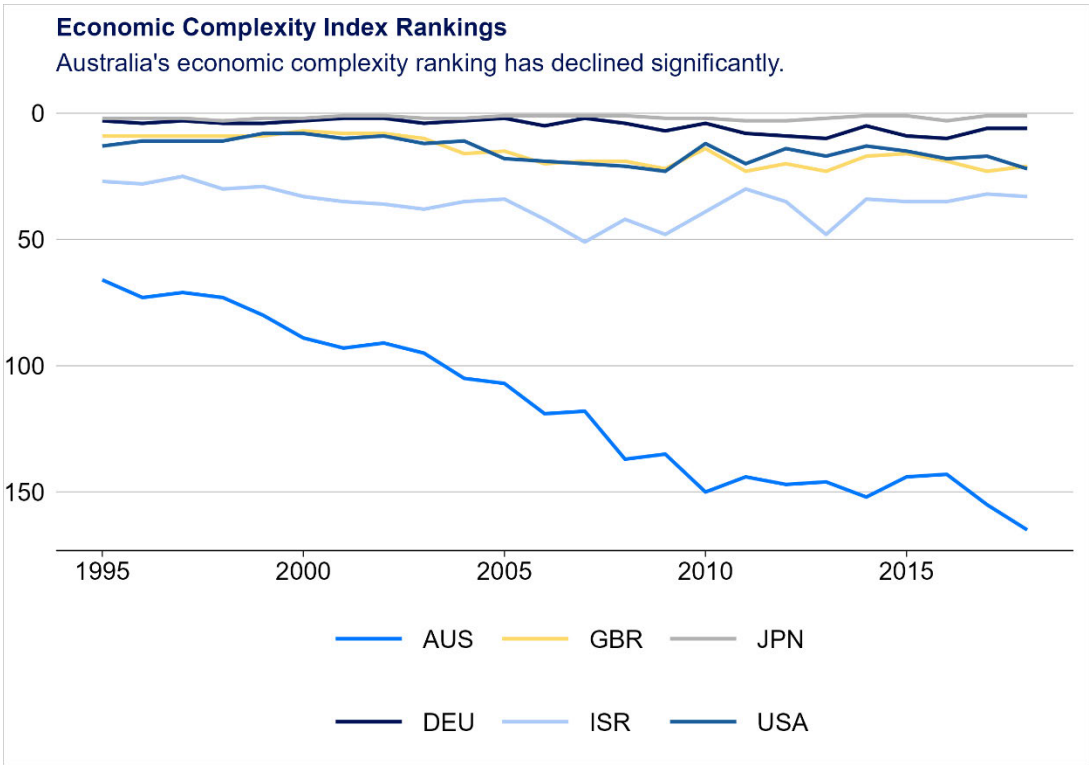
Economic complexity analysis determines how related capabilities, materials and assets can be leveraged to provide and scale up for items which may be needed in the future if critical times arise. Economic complexity analysis identifies where productive capabilities in an economy lie. Productive capabilities are identified by an assessment of the revealed comparative advantage in a product for a country, measured by the value of exports of that product relative to total world trade.

[3] It is important to differentiate between economic or product complexity and 'technical complexity'. Where two regions may use very different technologies to extract minerals, the product which is exported has the same economic complexity

7.1 Economic complexity and export competitiveness

Australia's level, and ranking in economic complexity has been declining almost consistently since 1995 when it was ranked as the 66th most complex country. By 2018, Australia's complexity ranking has declined to 165th most complex (see Figure 7-1).

Figure 7-1: Economic complexity - Australia and others



Source: The Growth Lab at Harvard University (2021)

According to the complexity model, Australia's income per capita far exceeds what would be expected from a country with such a low level of economic complexity.

The reasons for Australia's poor rankings in economic complexity are three-fold.

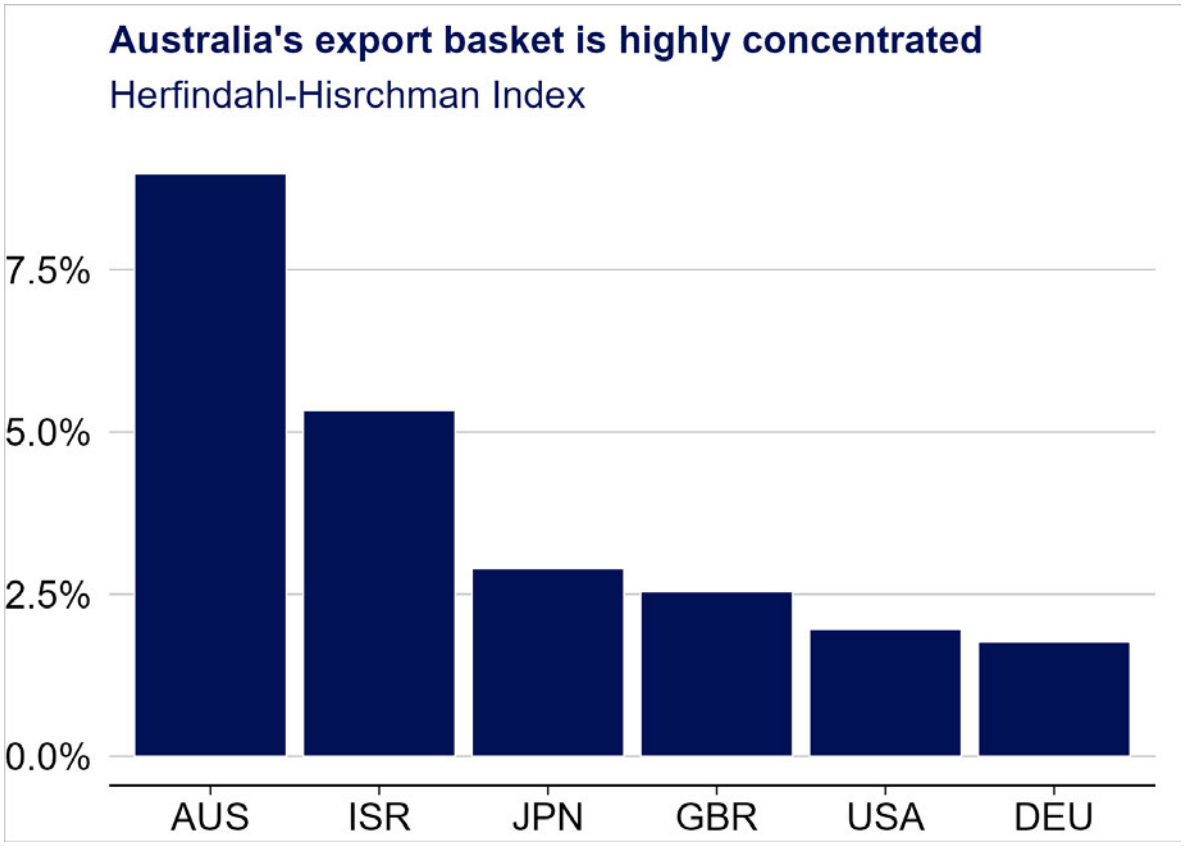
1. The total volume of exports from Australia is inflated due to significant exports of products such as coal, iron-ore, petroleum gas, and non-monetary gold.

Out of 1,220 products, more than 14% of Australia's total export value was generated by coal exports alone in 2018. More than half of total exports were from the export of five products: coal, iron ore, classified products[4], petroleum gas, and (non-monetary) gold. More than three quarters of total exports come from only 15 products. Of these 15 products, only two undergo significant transformation before export – wine, and refined petroleum. Such a skewed export basket has the effect of greatly diminishing the share of export value generated by other more complex

[4] Classified products include uranium

manufactured goods. Figure 7-2 below highlights Australia's concentrated export basket compared to the diverse export portfolio of five other countries.

Figure 7-2: Australian export concentration



Source: The Growth Lab at Harvard University (2019)

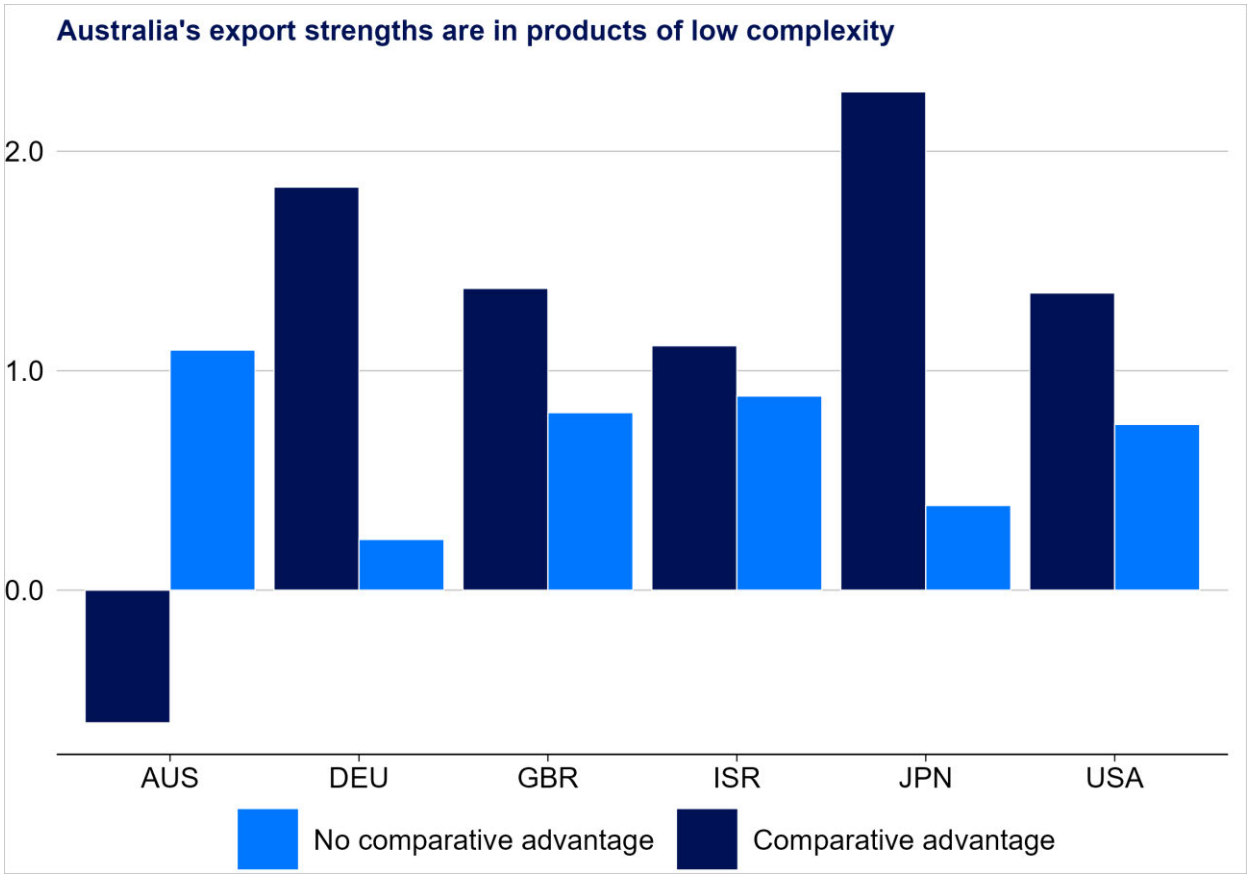
2. Minimal onshore processing of raw materials along the value chain to products of higher complexity (i.e., iron ore to steel).

Unprocessed materials such as raw minerals and raw agricultural products are low in economic complexity. The ability to export raw minerals is mostly correlated to their geographical presence, rather than a set of manufacturing skills or know-how, and the ability to export unprocessed wheat, wool, and meat is representative of Australia's abundance of land. Products which use these materials as inputs however tend to be much higher in complexity, are more indicative of manufacturing capabilities which can more easily be redirected into other areas if the need arises. Hot-rolled stainless-steel bars for example are the 17th most complex product in world trade. Australia's onshore processing of its resources has declined markedly over the past two decades.

3. The products which Australia exports at a share greater than world average[5] are on average much lower in complexity than those in which it does.

Products high in complexity are representative of a higher level of embedded knowledge within a region. The more the embedded knowledge, the easier a nation finds leveraging their capabilities towards products which it does not yet know how to produce. Figure 7-3 shows the difference in the average complexity between products exported with and without comparative advantage. Australia is the only country of the six to have a polarity between the two categories.

Figure 7-3: Average product complexity of products exported by export status

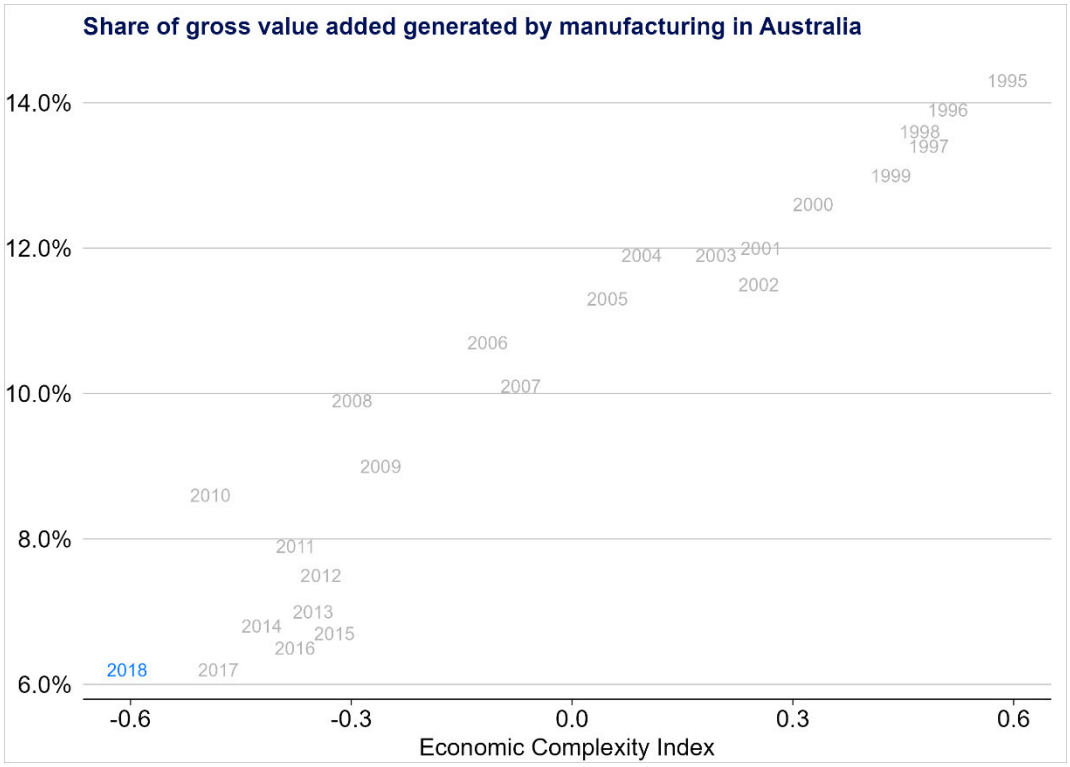


7.2 Manufacturing competitiveness

Figure 7-4 shows the relationship between the strength of Australia's manufacturing industry and its economic complexity index between 1995 and 2018.

[5] Officially, this is termed 'comparative advantage'. See Appendix B Revealed Comparative Advantage for the definition of comparative advantage.

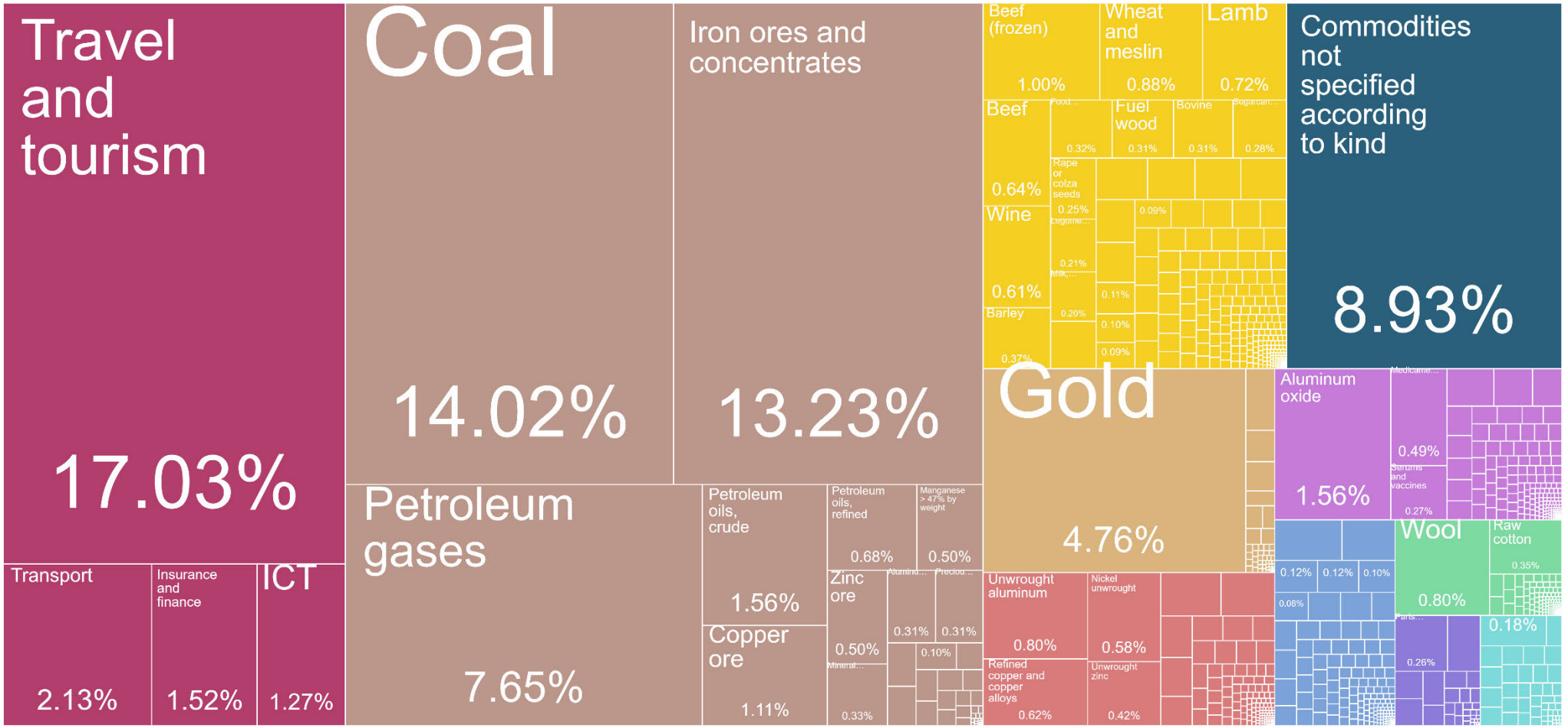
Figure 7-4: Gross value-added by manufacturing in Australia



Source: Author's calculations from The Growth Lab at Harvard University (2021) and Australian Bureau of Statistics (2020)

Table 2 showed how Australia was recently ranked last among OECD nations for manufacturing self-sufficiency based on the growing dependence of Australian merchandise exports on unprocessed and barely processed resource products, combined with Australia's reliance on imports of value-added manufactured products from other countries. The manufacturing trade deficit of elaborately transformed manufactures in 2019 was over $180 billion, representing 9% of national GDP (Stanford, 2020).

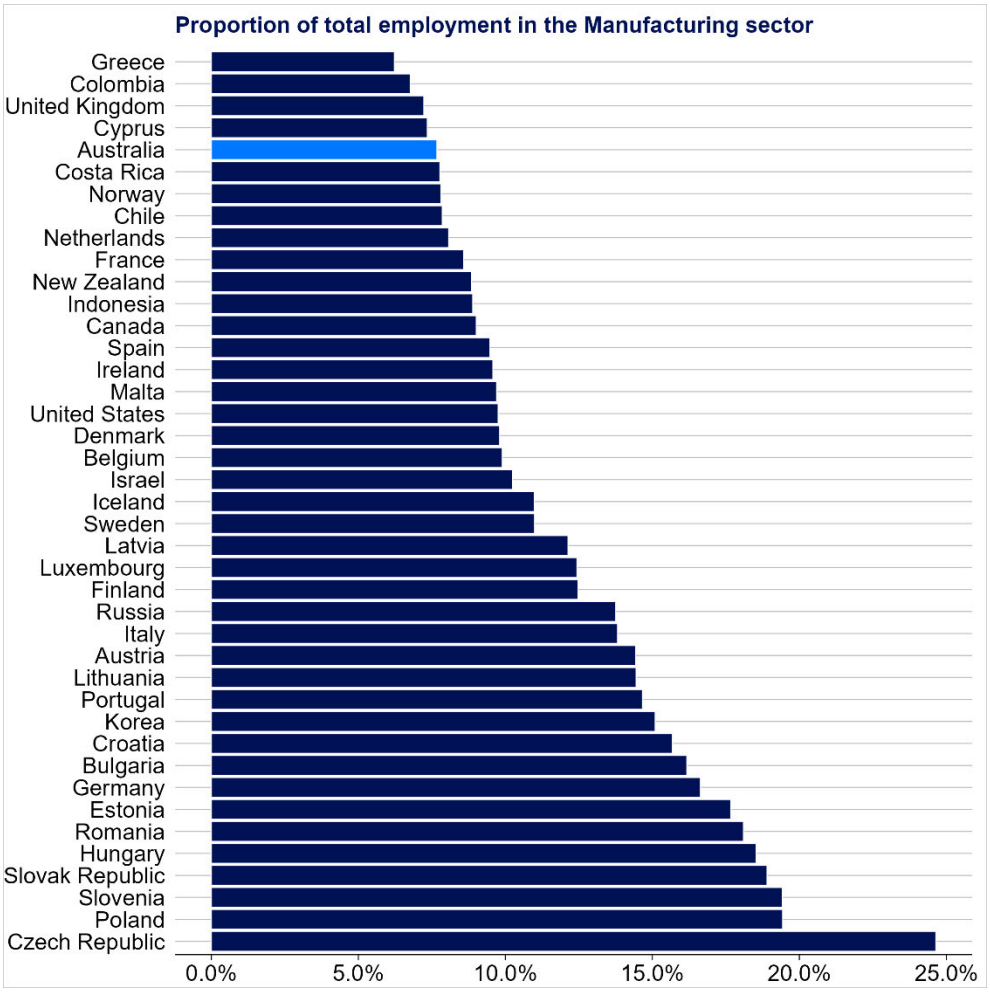
Figure 7-5: Composition of Australia's exports, 2018



Source: The Growth Lab at Harvard University (2019)

Manufacturing employment in Australia makes up about 7% of total employment. This is very low and far lower than in all but a few other OECD economies (see Figure 7-6).

Figure 7-6: Manufacturing employment



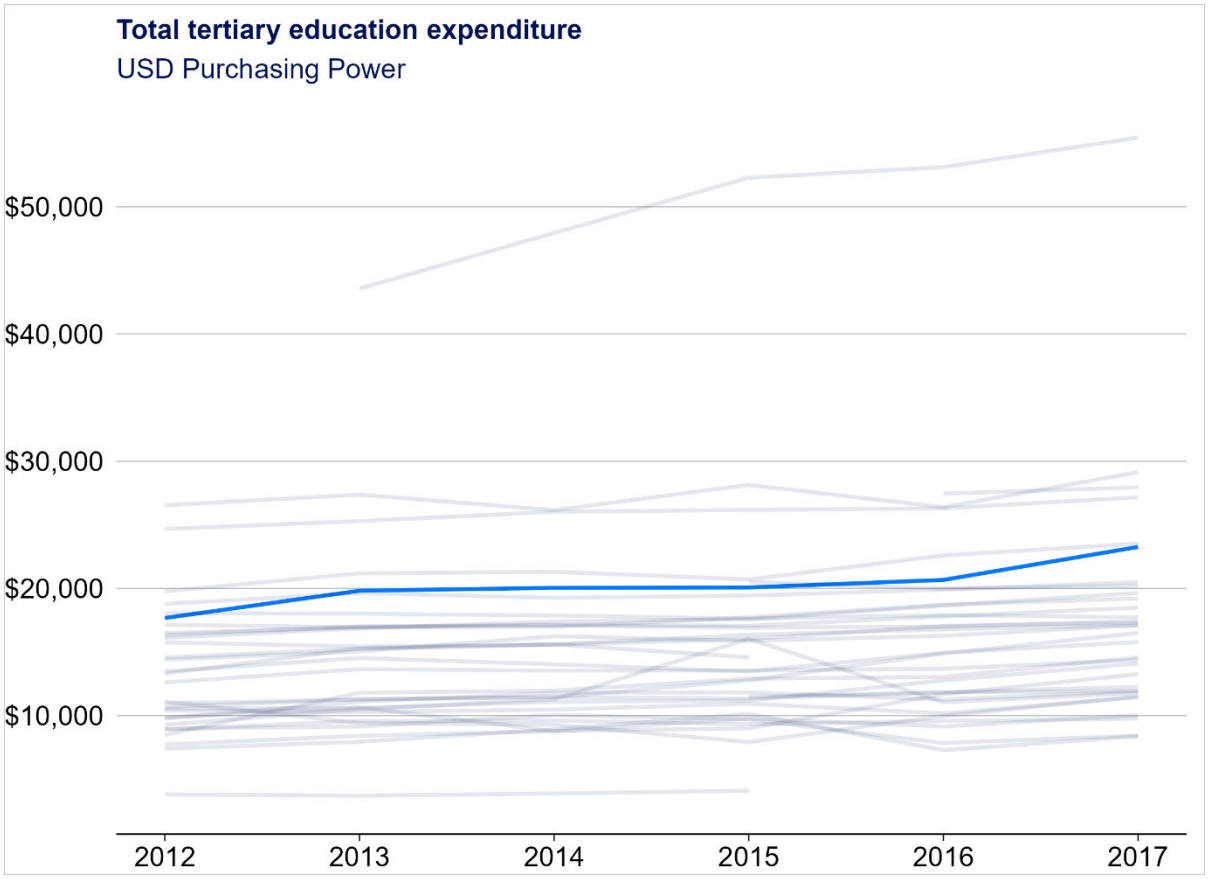
Source: OECD (2021a)

7.3 Education competitiveness

Australia's total expenditure on tertiary education per FTE student ranks relatively highly amongst other OECD countries. Figure 7-7 shows that Australia invests about US$25,000 per FTE student in tertiary education. Luxembourg invests the most, at more than US$50,000 per FTE student. Other countries ranking higher than Australia include Great Britain, Canada, Sweden, and Norway.

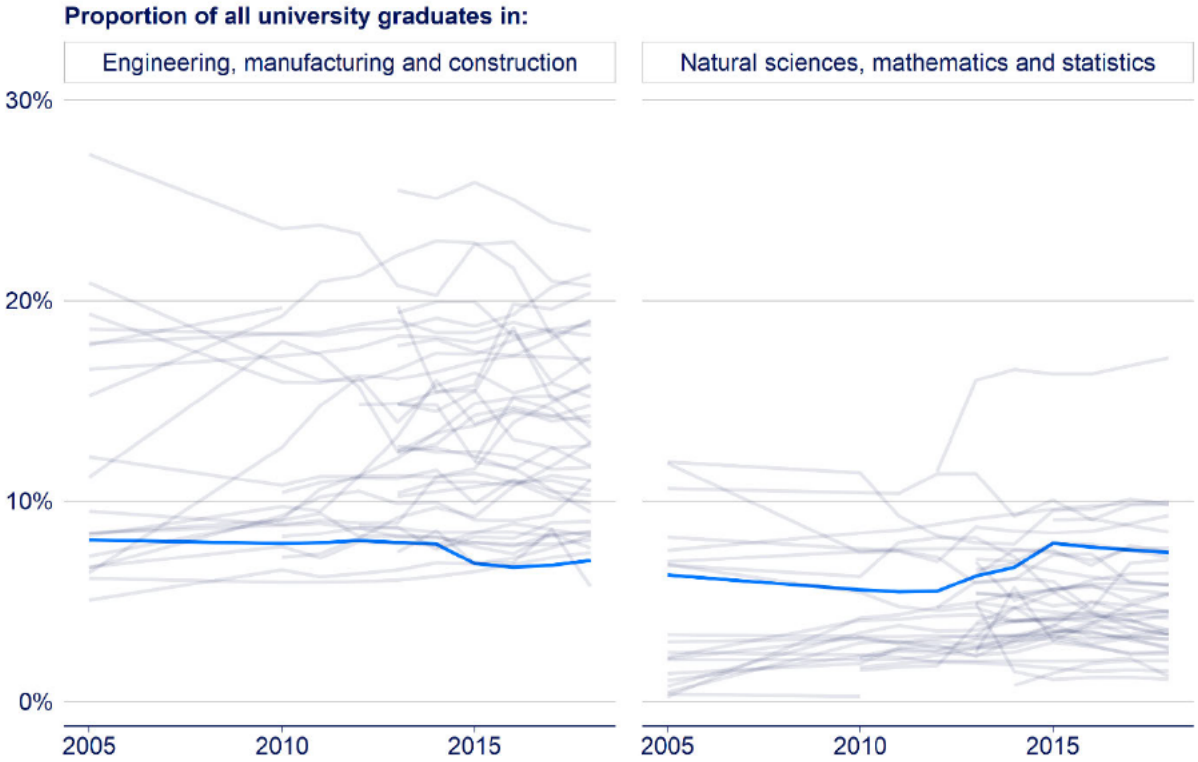
This has not necessarily resulted in Australia ranking highly in education outcomes. Figure 7-8 shows the proportion of all university graduates in a) engineering, manufacturing and construction, and b) natural sciences, mathematics, and statistics. While the proportion of Australian university graduates in the natural sciences is about average for the OECD, Australia ranked second last in 2017 for engineering graduates.

Figure 7-7: Tertiary education expenditure (US$) per FTE student



Note, Australia highlighted in light blue. All other OECD countries in grey.
Source: OECD (2020)

Figure 7-8: Australian education outcomes



Note, Australia highlighted in light blue. All other OECD countries in grey.
Source: OECD (2020)

7.4 Digital competitiveness

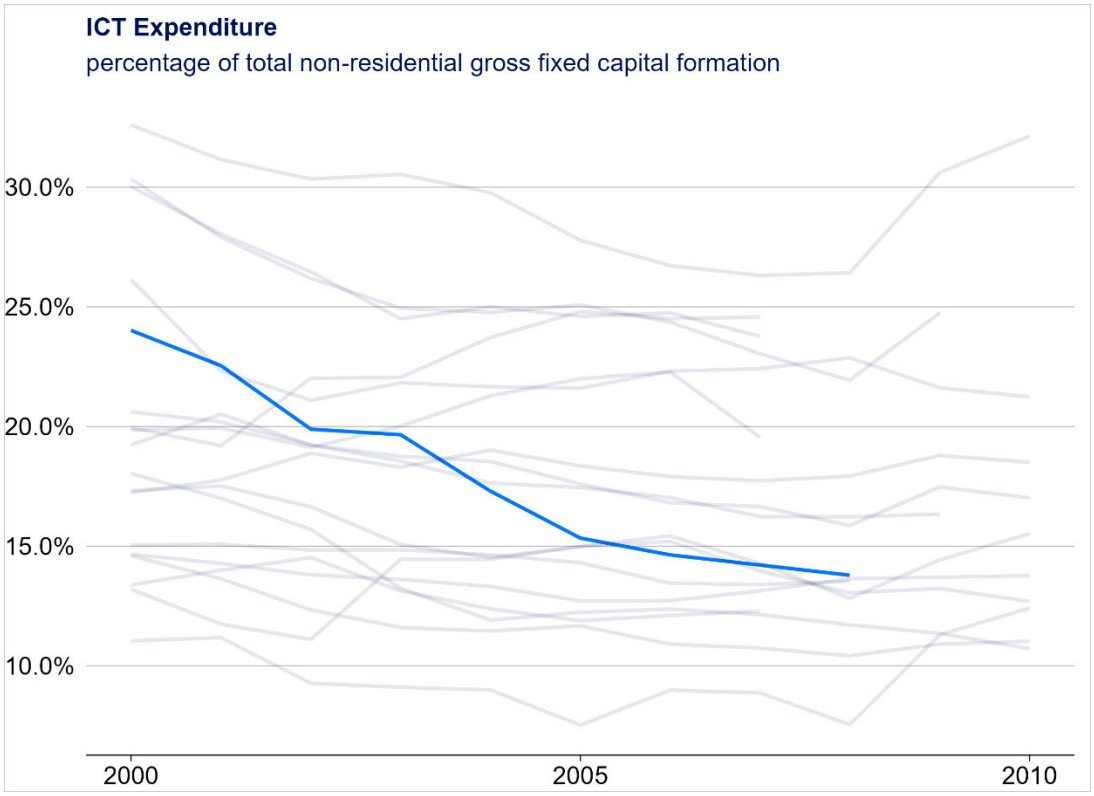
The 2020 world digital competitiveness rankings placed Australia at 15 [h] out of 63 economies, down from 14th in 2019 (IMD, 2020). Table 7 below shows Australia's rankings in knowledge, technology, and future readiness for 2019 and 2020.

Table 7: Australian digital competitiveness

Category	2020 Ranking (2019 Ranking)
Knowledge	17 (15)
Technology	14 (14)
Future Readiness	17 (14)

Australia's digital competitiveness ranking strengths are in net flow of international students, investment in telecommunications, credit rating, mobile broadband subscribers, and tablet possession. Australia's weaknesses are in science graduates (53rd), high-tech patent grants (44th) communications technology (51st), agility in response to opportunities and threats (45 [h]) and agility of companies (48th). Australia's investment into the ICT sector is also middling amongst OECD members (see Figure 7-9). Although the data are relatively old, there was a clear downward trend in ICT investment as a proportion of all non-residential gross fixed capital formation between 2000 and 2010 in Australia.

Figure 7-9: ICT Capital Expenditure

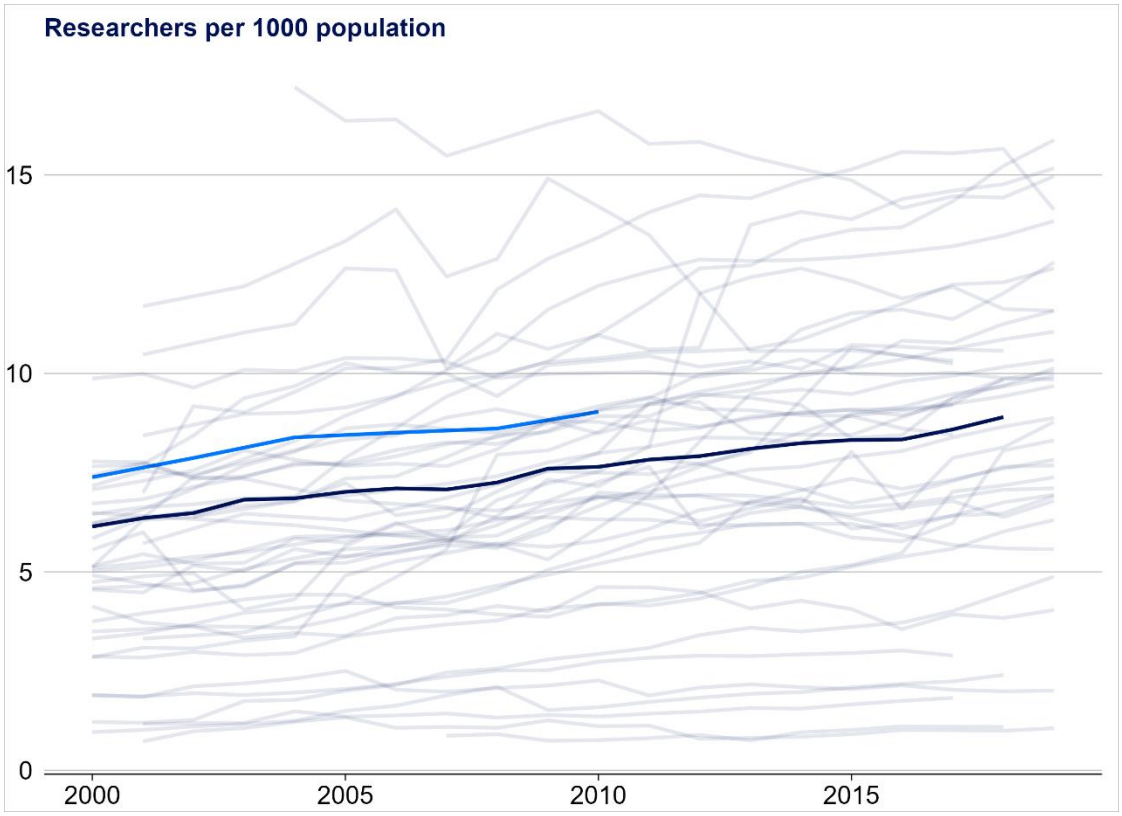


Note, Australia highlighted in light blue. All other OECD countries in grey.
Source: OECD (2021c)

7.5 Research competitiveness

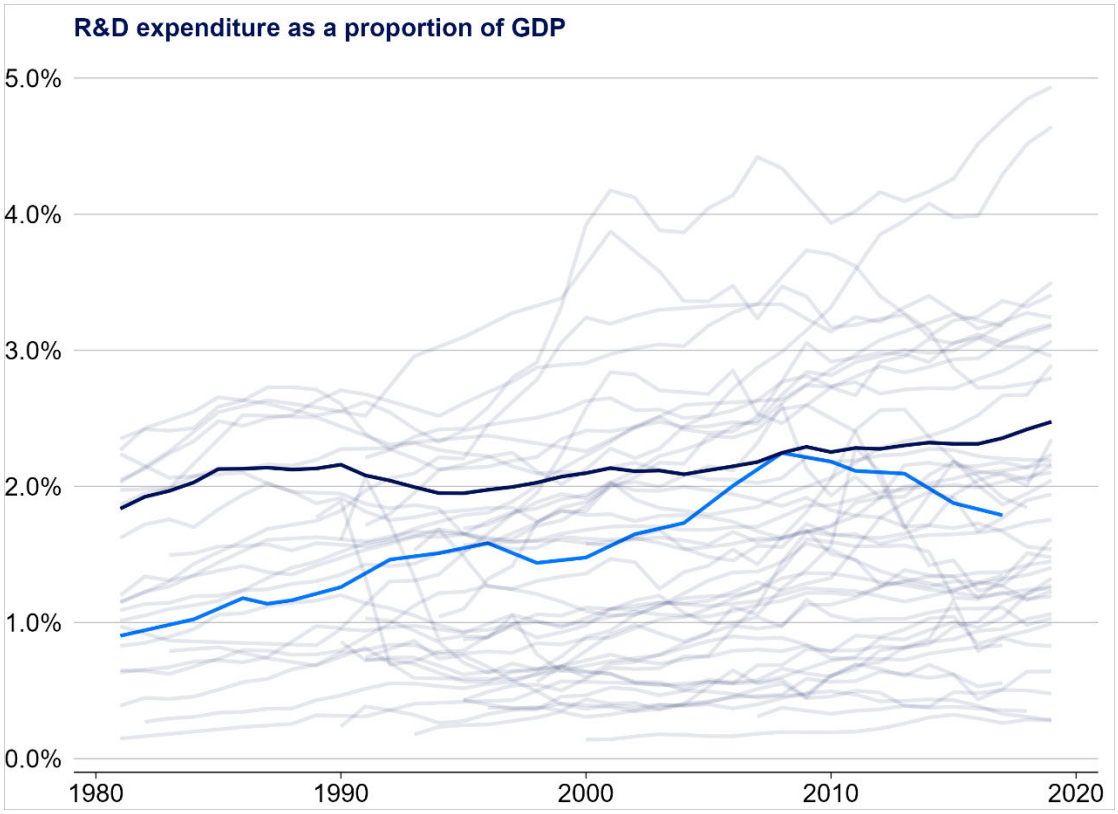
The latest available data for Australia show that while the number of researchers per capita is higher than the OECD average, it is still modest at a bit below 10 per 1000. This is significantly fewer than Korea (16 per 1000), Sweden and Finland (15 per 1000, see Figure 7-10). In terms of research and development expenditure as a proportion of GDP (see Figure 7-11), Australia lags other OECD nations with R&D expenditure of 1.8% of GDP in 2017 compared to the OECD average of 2.5%. Israel tops the indicator with R&D expenditure of almost 5% of GDP, followed by Korea (4.6%) and Taiwan (3.5%). Australia's level of R&D expenditure is more like that of Canada (1.5%), Great Britain (1.8%) and the Czech Republic (1.9%).

Figure 7-10: Australian researchers per capita



Note, Australia highlighted in light blue. All other OECD countries in grey. The OECD average is highlighted in dark blue.
Source: OECD (2021e)

Figure 7-11: Australia R&D expenditure as a proportion of GDP



Note, Australia highlighted in light blue. All other OECD countries are in grey. The OECD average is highlighted in dark blue.
Source: OECD (2021b)

However, research competitiveness is not a function solely of investment on the supply side, but also of sharpening the demand side to lift translation of research to economic and industrial development. Australia rates very poorly on translation and application of research into economic and commercial outcomes. Against international benchmarks, Australian industry is rated has having low 'capacity for innovation'; there is low co-production of research with industry; there is a poor 'state of cluster development' and low 'value chain breadth'; and finally, there is low investment in 'intangibles'. Intangibles investment covers organisational and human capital, R&D and investment in ICT – many of the things that enable a company to absorb and embed innovation (Roos, 2013, pp. 108-111).

Reinforcing these points, the Global Innovation Index Innovation Efficiency Ratio (the comparison of inputs to innovation outputs) ranks Australia 81st of 143 nations, with non-residents filing 90 percent of patents in Australia in 2012 (World Intellectual Property Indicators, 2013). Australia rates poorly in proportions of researchers working with industry, incidence of co-authored industry and research papers, and on new-to-world innovations (Ibid). More recent data from these and similar sources confirm the picture. The latest World Economic Forum data confirm a decline in Australia's ranking for 'innovative capability' and 'multi-stakeholder collaboration (Schwab, 2019, p. 69). Similarly, Australia rates particularly poorly on collaboration for innovation in international rankings, including coming last (29th) in the OECD for SME collaboration with universities (Office of the Chief Economist, 2017). A recent OECD survey of

Australia (Koutsogeorgopoulou & Park, 2017) adds to the picture painted above, finding that:

- Gross Expenditure on R&D (GERD) as a percentage of GDP is middle-ranking in the OECD, but consistently below the OECD average, (Australia's GERD is 1.9% of GDP, compared to the OECD average of 2.4%.)
- Innovation input is stronger than output
- Australia can make more of its R&D spending
- Australia is well above the median for inputs
- Output measures are less impressive with low 'new-to-market' innovations, even compared to other resource rich economies (noting the generally lower R&D efforts of extractive industries)
- Australia has a low proportion of R&D active businesses
- Australia performs poorly in translating publicly funded research into commercial outcomes
- There is weak collaboration between the research and business sectors
- Tax incentives form the core of Australia's financial support for business R&D, particularly the R&D Tax Incentive, with questionable additionality (the extent to which the scheme funds additional R&D or effectively subsidises that R&D which would have occurred in any event).

8 Conclusion

Australian industry, government and citizens have experienced a dramatic shock to global supply chains resulting from the COVID-19 pandemic, highlighting Australia's often acute dependence on other countries for the supply of goods and services. This has brought to the fore the importance of domestic manufacturing capabilities, as well as the importance of domestic capabilities in other key areas such as fuel supply and refining capabilities and health and medical supplies. Fear of repeated disruptions in the future, associated either with further pandemic or heightened international tensions have created a sense that Australia must become more self-sufficient.

Sovereign capability is a concept with strategy and strategic considerations at its root. This means identifying the decisive points that will provide greatest strategic advantage to Australia in increasing its overall sovereign capabilities and applying the required means to those decisive points. It recognises that limited resources and capacity for force cannot be effective if it is expended in any and all directions. It must be directed at a target.

It is the opposite of a scatter gun approach and of a policy of autarchy. It is about isolating those things which Australia must be able to make and to do to achieve the key areas of the national interest: population health, defence, security of energy and basic materials and infrastructure, scientific and technological capability, and the ability to make things itself (manufacturing).

For this reason, sovereign capability is not about total autonomy of production, design, industry, ownership and labour within Australia. There is more to be gained from developing sovereign capabilities in a way in which Australia still participates in global supply chains. Static comparative advantage orthodoxy, derived from drastically simplified and highly unrealistic Ricardian premises originating 200 years ago, has helped drive poor policy directions for Australia's industrial structure and perverse decisions about what the nation should specialise in. Trade and industrial specialisation are nevertheless vital sources of economic gain for nations and regions (Krugman, 1981, 1991). The types of gain involved (scale, knowledge and path-dependent capacity for further knowledge gain and application, and cumulative causation) are linked much more to having strategic policy and public intervention than to following comparative advantage. This is the critical distinction.

Sovereign capability must become a robust national policy objective beyond its current confines in Defence (where original aims are themselves being diluted). Fundamentally this means prioritising:

- Production (broadly conceived to include preproduction design, direct production, systems and systems integration, capacity for through-life support, etc.). Direct production remains the condition for the successful capture of these vital pre- and post-production elements. Sovereign capability is not achieved without the ability to produce goods that are of strategic value and importance to the national interest; and
- Policy: the extent to which government prioritises sovereign capability imperatives to identify and then address the decisive points for leverage and impact. This requires conscious and purposeful directions-setting for the future development of the economic, technological, organisational, logistic and operational capacities of the nation.

Other elements of sovereign capability depend on having these priorities as their recognised and explicit basis.

Treating sovereign capabilities as points on a spectrum, built upon the inputs of design, systems integration, local industry content, direct production, business ownership, and local workforce participation, allows for identification of more important capabilities and for us to be able to assign them levels of priority towards the overall goal of greater sovereignty. These considerations interact with existing industry structure, the character of international value chains pertaining to each domain, the role and nature of foreign ownership, etc.

Australia requires strategic interventionist policy for greater sovereign capability. Some of the key elements are sectoral policies for development of the key industry verticals and secondary processing, greater domestic production, clear national goals and strategies relating to selected areas (especially energy security), an expert national authority responsible for policy and outcomes relating to building and measurement of Australian capability and industry participation, aggregating projects to build scale, etc.

The scope of this inquiry does not involve precise specification of the decisive points for greater sovereignty in each sector. This report has indicated where to look for the discovery and analysis of those precise decisive points. A more comprehensive set of studies along the lines of the tops-down Biden Executive Order on supply chains and sovereign capability is an urgent priority for Australia.

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Appendix A. Consumer Campaigns

In this Appendix, we describe historic public awareness campaigns. These are not themselves evidence of a strategic sovereign capability approach; they do not focus on what Australia needs to be able to make and do to achieve defined national goals. Rather, they concentrate on public attitudes to local purchasing, mostly of consumer final goods. They are not guided by or directed toward substantive overarching policy or industry development goals or outcomes. However, the campaigns have led to some useful perspectives on definitions of Australian 'made', 'product' and 'grown' as applied to food products. This example also illustrates frequent slippage of definition.

While the importance of sovereign capabilities has received much attention recently, the importance of buying, and promoting Australian products has been prevalent in Australia since the 1961 "Operation Boomerang" campaign was introduced by Prime Minister Robert Menzies. This campaign, launched by the Associated Chambers of Manufactures of Australia, aimed to encourage people to buy locally made goods, and to strengthen the profile of local manufacturing.

In 1986, Prime Minister Bob Hawke also promoted the importance of Australian made through the "Australian Made" campaign and logo. This scheme introduced the iconic and recognisable Australian Made logo with this used widely and successfully for a variety of products including food, furniture, clothing, lifestyle, homewares, and souvenirs. Today the logo has 99% recognition, is trusted by 92% of Australians and has encouraged Australians to think about buying Australian products (Roy Morgan, 2020). It is also used internationally to promote Australia's status a safe and reliable source of food and other products.

The definition of Australian Made has evolved over time. Since 1 July 2018, the definition was strengthened to include mandatory labelling, and the introduction of distinct categories of Australian Made food products. Under this scheme, a product can only be labelled as Australian Made if its last substantial transformation occurred in Australia, where a substantial transformation occurs if the product was grown or produced in Australia, or if a process carried out in Australia fundamentally changes the identity, nature, or character from its imported ingredients or components. The categories are summarised in Table 8.

Table 8: Classification of Australian made food products

Designation	Rules
Australian Product	• Ingredients come from Australia • Production occurs in Australia
Australian Made	• Substantial transformation occurs in Australia • Country of origin of imported ingredients specified
Australian Grown	• Significant ingredients grown in Australia • All production of the good occurs in Australia

Each of the classifications of Australian made food products could be considered in the context of sovereign capabilities, yet each would have a different interpretation. An *Australian Grown* product represents the capability to produce raw materials, an *Australian Made* product represents the capabilities to process products which may not be naturally available in Australia, and an *Australian Product* represents the combination of the two, and provides a higher degree of sovereign capability than Australian Made or Grown. Other industries should look to the

Australian Made campaign and classification methodology for defining what sovereign capabilities need to look like for their industry.

Appendix B. Economic Complexity

The key outputs from economic complexity analysis include a description of the products in which a country has capabilities, based on the products which are exported with revealed comparative advantage, a level of economic complexity which is comparable across countries and across time, and a ranking of product complexity. This study follows the method for calculating economic complexity as developed by Hausmann and Hidalgo and uses the dataset published by The Growth Lab at Harvard (The Growth Lab at Harvard University, 2019). An explanation of the indicators, and their derivation is provided below:

Revealed Comparative Advantage

Revealed comparative advantage (RCA) is a measure of the level of comparative advantage which a country possesses for a given product:

$$RCA_{cp} = \frac{X_{cp}}{\sum_c X_{cp}} / \frac{\sum_p X_{cp}}{\sum_{cp} X_{cp}}$$

Values of *RCA* over 1 indicate that a country has comparative advantage in the production of that product. That is, the share of the country's total exports captured by a product to its total exports is greater than the share of the world's total exports captured by the world's exports of that product. Comparative advantage in the production of a product is a useful proxy for a country's level of productive capabilities. The RCA is converted into a matrix M_{cp} with value 1 if the country-product pair has RCA greater than 1, and 0 otherwise.

Economic Complexity Index

The economic complexity index (ECI) is the level of complexity embedded in an economy, based on the complexity, ubiquity ($k_{p,0}$), and diversity ($k_{c,0}$) of the products they export. Highly complex economies export many highly complex (knowledge intensive) products, which in turn are exported by relatively few economies. The derivation of the Economic Complexity Index uses diversity (the number of products an economy exports with RCA>1) and ubiquity (the number of economies that export a product with RCA>1):

$$M_{cc} = \sum_p \frac{M_{cp} M_{c'p}}{k_{c,0} k_{p,0}}$$

The ECI is the eigenvector corresponding to the second largest eigenvalue of M_{cc}

Product Complexity Index

The Product Complexity Index (PCI) is the level of complexity embedded in a product, based on the complexity and the ubiquity of economies which export them. Highly complex products are non-ubiquitous products which are exported by complex economies. There is a recursive relationship between ECI and PCI, as can be seen by the similarity between the M_{cc} and M_{pp} matrices. The Product Complexity Index is the eigenvector corresponding to the second largest eigenvalue of M_{pp}.

$$M_{pp} = \sum_{c} \frac{M_{cp} M_{cp'}}{k_{c,0} k_{p,0}}$$

Proximity

The proximity between two products measures the relatedness of those two products based on the productive knowledge required to export them with comparative advantage. It is based on the proportion of economies which export both products with comparative advantage.

$$\phi_{pp'} = \frac{M_{cp} M_{cp'}}{\max\left(k_{p,0}, k_{p',0}\right)}$$

Density

Density provides an indication of how near an economy is from the productive knowledge required to export a new product with Revealed Comparative Advantage. The density for a product is the proportion of related knowledge that the economy has revealed comparative advantage in, weighted by the proximity between the related products and the target product. Density can also be referred to as Distance where Distance = 1 – Density.

$$d_{cp} = \sum_{p'} \frac{\left(1 - M_{cp'}\right) \phi_{pp'}}{\sum_{p'} \phi_{p,p'}}$$

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